HOUSE OF COMMONS SESSION 1999–2000

# SCIENCE AND TECHNOLOGY COMMITTEE

## Second Report

# ENGINEERING AND PHYSICAL SCIENCES BASED INNOVATION

## Volume II

## Appendices to the Minutes of Evidence

*Ordered by* The House of Commons *to be printed*
*31 January 2000*

LONDON: THE STATIONERY OFFICE
£18·00

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195–II

## The Science and Technology Committee

The Science and Technology Committee is appointed to examine on behalf of the House of Commons the expenditure, administration and policy of the Office of Science and Technology (and any associated public bodies). Its constitution and powers are set out in House of Commons Standing Order No. 152.

The Committee has a maximum of eleven members, of whom the quorum for any formal proceedings is three. The members of the Committee are appointed by the House and unless discharged remain on the Committee until the next dissolution of Parliament. The present membership of the Committee is as follows:[1]

Dr Michael Clark MP *(Conservative, Rayleigh)*[2]
Mr Nigel Beard MP (*Labour, Bexleyheath and Crayford*)[2]
Mrs Claire Curtis-Thomas MP (*Labour, Crosby*)[2]
Dr Ian Gibson MP (*Labour, Norwich North*)[2]
Mr Robert Jackson MP (*Conservative, Wantage*)[3]
Dr Lynne Jones MP (*Labour, Birmingham Selly Oak*)[2]
Mr Nigel Jones MP (*Liberal Democrat, Cheltenham*)[2]
Dr Ashok Kumar MP (*Labour, Middlesborough South and East Cleveland*)[2]
Mr Ian Taylor MP (*Conservative, Esher and Walton*)[4]
Dr Desmond Turner MP (*Labour, Brighton Kemptown*)[2]
Dr Alan W Williams MP (*Labour, Carmarthen East and Dinefwr*)[2]

On 30 July 1997, the Committee elected Dr Michael Clark as its Chairman.

The Committee has the power to require the submission of written evidence and documents, to examine witnesses, and to make Reports to the House. In the footnotes to this Report, references to oral evidence are indicated by 'Q' followed by the question number, references to the written evidence are indicated by 'Ev' followed by a page number.

The Committee may meet at any time (except when Parliament is prorogued or dissolved) and at any place within the United Kingdom. The Committee may meet concurrently with other committees or sub-committees established under Standing Order No. 152 and with the House's European Scrutiny Committee (or any of its sub-committees) for the purpose of deliberating, taking evidence or considering draft reports. The Committee may exchange documents and evidence with any of these committees, as well as with the House's Public Accounts, Deregulation and Environmental Audit Committees.

The Reports and evidence of the Committee are published by The Stationery Office by Order of the House. All publications of the Committee (including press notices) are on the Internet at www.parliament.uk/commons/selcom/s&thome.htm. A list of Reports of the Committee in the present Parliament is at the end of this volume.

All correspondence should be addressed to The Clerk of the Science and Technology Committee, Committee Office, House of Commons, London SW1A 0AA. The telephone number for general inquiries is: 020 7219 2794; the Committee's e-mail address is: scitechcom@parliament.uk.

[1] Mrs Caroline Spelman MP (*Conservative, Meriden*) was appointed on 14 July 1997 and discharged on 22 June 1998.
Mr David Atkinson MP (*Conservative, Bournemouth*) was appointed on 14 July 1997 and discharged on 30 November 1998.
Mrs Jacqui Lait MP (*Conservative, Beckenham*) was appointed on 22 June 1998 and discharged on 5 July 1999.
[2] Appointed on 14 July 1997.
[3] Appointed on 5 July 1999.
[4] Appointed on 30 November 1998.

# LIST OF WITNESSES

## LIST OF MEMORANDA INCLUDED IN THE MINUTES OF EVIDENCE

# LIST OF APPENDICES TO THE MINUTES OF EVIDENCE VOLUME II

*Memoranda from:* *Page*

## UNPRINTED MEMORANDA

Additional Memoranda have been received by the following and have been reported to the House, but to save printing costs they have not been printed and copies have been placed in the House of Commons Library where they may be inspected by Members. Other copies are in the Record Office, House of Lords, and are available to the public for inspection. Requests for inspection should be addressed to the Record Office, House of Lords, London, SW1. (Tel 0171-219 3074). Hours of inspection are from 9.30 am to 5.30 pm on Mondays to Fridays.

1. Gatsby Charitable Foundation
2. Appendices to Memorandum submitted by Ms K Marjorie de Reuck
3. Appendices to Memorandum submitted by the Silsoe Research Institute
4. Appendices to Memorandum submitted by the Association of Independent Research and Technology Organisations
5 Annexes to Memorandum submitted by the Construction Research and Innovation Strategy Panel
6. Annex to Memorandum submitted by the TEC National Council
7. Annexes to Memorandum submitted by NatWest Group Innovation and Growth Unit
8. Annex and Appendices to Memorandum submitted by the Institute of Inventors
9. Appendix to Memorandum submitted by Dr Malcolm Skingle
10. Memorandum, Annex, and Appendices submitted by Microsoft Limited
11. Annex to Memorandum submitted by Smiths Industries plc
12. Annex to Memorandum submitted by 3i Group plc
13. Annex to Memorandum submitted by Scottish Software Partners Centre
14. Annex to Memorandum submitted by Bookham Technology
15. Department of Trade and Industry

# APPENDICES TO THE MINUTES OF EVIDENCE

## TAKEN BEFORE THE SCIENCE AND TECHNOLOGY COMMITTEE

### APPENDIX 1

**Letter to the Clerk of the Committee from Mr Martin Gagen, Head of UK Investment, 3i Group plc**

Thank you for your letter of 15 December asking whether we would like to submit a supplementary memorandum to the committee by the end of January.

We responded to your initial invitation to produce evidence to your committee because we are firmly committed to investing in and supporting the growth of promising technology-based businesses. Since giving evidence, our support has continued to grow and we have expanded our own programme of research into ways of creating more such companies and supporting them more effectively. I would like to highlight some of that ongoing work here:

1. *Capital Gains Tax*. The debate about encouraging innovation and new business creation now recognises the complex nature of the issues and the difficulty of creating rapid cultural change that is durable. In our view the capital gains tax rate is the only simple lever available for catalysing change that has been identified and proven elsewhere. The evidence shows that where countries have reduced CGT to materially lower levels than in the UK, there has been a major beneficial impact in new business creation. Furthermore it is increasingly evident that the best entrepreneurs are geographically mobile and that the UK needs to measure its CGT rates against international yardsticks.

We attach a Budget submission for 1999–2000 that summarises our views[1].

2. *Corporate Venturing*. Since our submission to the Committee, we have seen increasing activity by large corporates in "venturing" and investing in interesting technology businesses. We now have close relationships with several such international businesses and one has already made a number of investments alongside us. Workable models of corporate venturing have been rare, both internationally and in the United Kingdom.

We could be witnessing, however, the beginning of a sea-change in corporate attitudes, driven largely by the increasing difficulty faced by in-house research groups in keeping abreast of technology developments globally. In consequence, we are sponsoring research into the area by the Judge Institute in Cambridge and expect their initial output this summer. If the Committee is still sitting then, we would be pleased to provide relevant information.

3. *"University Challenge"* We continue to be actively involved in seed funding and keen to ensure the success of projects such as "University Challenge". We have expressed our views on this subject to the Committee and elsewhere before but, in brief, we remain concerned that such funds should be concentrated, with sufficient critical mass, on excellence. One key issue, for example, is that any fund be of sufficient size to attract a seasoned individual as its manager/investor. Another is that the resources go to those situations that have the real potential to be large businesses. In this way, public money is more likely to stimulate successful projects which attract private sector management and investment. The sincerity of our views is reflected in our substantial recent investments in seed funds such as the Medical Research Council Fund and Cambridge's Quantum Fund.

4. *The European New Issues Markets.* One of the key ingredients in encouraging the venture capital industry to support young technology companies is the ready availability of later-stage support from stock markets. Since 1995 a number of new stock markets have been created in Europe, which is encouraging. On the other hand a number of more recent developments are reducing the markets willingness to support promising companies. In view of this complex picture we have sponsored research at Insead, where we have ongoing sponsorship of the "3i Venturelab", into the European New Issues Market. A copy of the preliminary review is attached[1].

I would like to thank the Committee for the opportunity to contribute to this important Inquiry. 3i is happy to provide any further assistance at any time.

*September 1998*

[1]*Not printed.*

## APPENDIX 2

### Memorandum submitted by AEA Technology

THE GROWTH PROCESS

AEA Technology plans to become a £500 million turnover business, doubling its size at the time of privatisation. This demands growth through both acquisition and organic means. In the months immediately following privatisation, a new process was developed and introduced to the company targeted at stimulating organic growth: The Growth Process. It was developed with McKinseys to achieve two key goals:

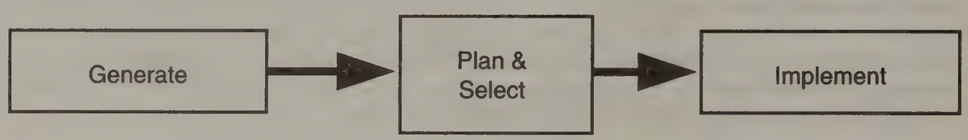
— stimulate innovation: taking technology to market; and

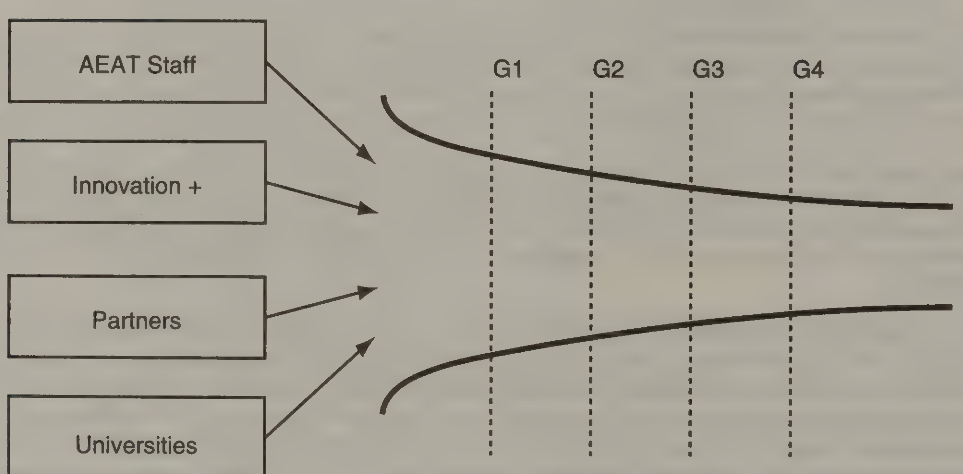
— transform company culture: from mission led (technology support to the nuclear industry) to market led (recognising and exploiting commercial opportunities).

At the heart of the Growth Process is the recognition that science and engineering companies like AEA Technology have a valuable set of capabilities (eg skills and technical abilities), assets (eg patents, know-how, facilities) and relationships (eg with partners, suppliers, customers) ie what the company can do exceptionally well. Realising their value means finding a match between such capabilities assets and relationships and market opportunities, often caused by sudden change. An example might be new environmental legislation, opening up an opportunity for pollution control technology.

The process itself has three main stages: idea generation, business planning and selection, and implementation.

**Growth Process Stages**




*Idea Generation*

New ideas for business development can be generated from a number of sources eg:

— Our own technical and sales staff;

— Innovation +: a specific initiative through which AEA Technology actively seeks to support other individuals with innovative ideas through the provision of business acumen, facilities, advice and technical assistance;

— Partners through industry links and venture capital providers; and

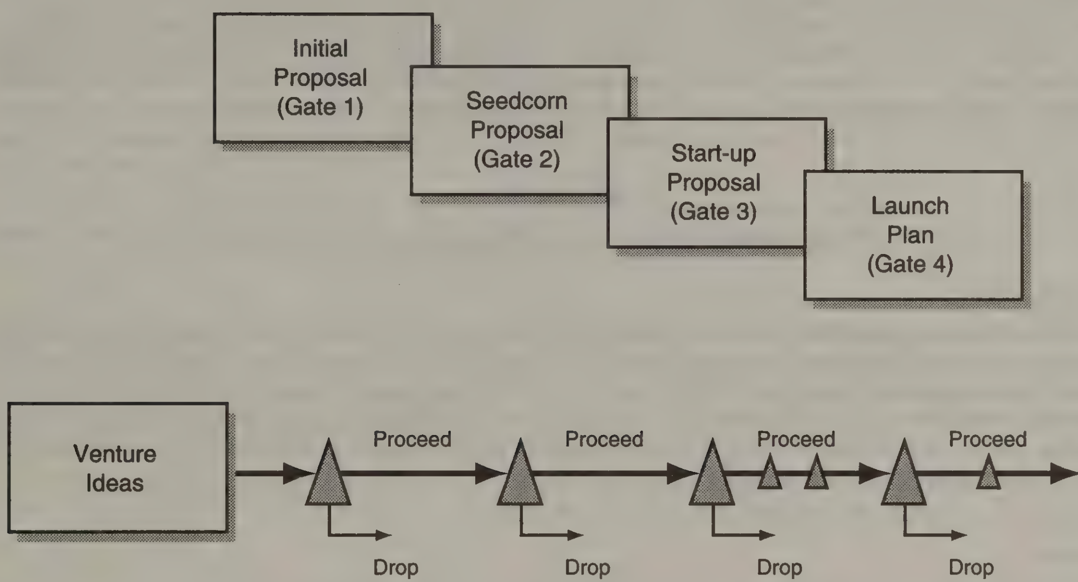
— Universities through targeted support of university research and the development of centres within selected universities.

New ideas are captured on a single page proforma which seeks to quantify at first level the key characteristics of the opportunity ie value to the customer, market size and growth, time to market, potential value to the company, necessary capabilities assets and relationships etc.

*Selection and Business Planning*

Each new venture idea then faces a series of decision gates through which it will either proceed, or be dropped, depending on its merit as judged against 10 key commercialisation questions. These questions form the basis for a business plan which is developed progressively as the idea passes through the gates. Investment funding is released initially to enable business plan development. Substantial investment if required, for example to fund technical development, is only released at gate three once sufficient confidence has been gained in the likely future returns.

**Investment driven by the Business Case**




*Implementation*

The final decision gate requires a clear implementation plan to be approved. This will identify what steps need to be taken in order to launch the new venture idea on the market, and may include setting up a new start-up business unit. AEA Technology has adopted a "New Ventures Board" approach for such ideas, whereby start-ups with potential for significant value generation are given special management attention within a unit which is deliberately separated from the main stream business. This provides the best possible environment for the particular needs of a start-up business, minimising the burden of corporate requirements which more mature business units carry.

AEA Technology ran the Growth Process at a corporate level for the first year. Since then, it has been installed in each of the 11 business units which comprise the AEA Technology Group, and continues to run at corporate level as well. Overall, more than 300 ideas have been assessed, of which 14 have been launched.

*15 December 1998*

## APPENDIX 3

**Letter to the Clerk of the Committee from Mr John Loughhead, Vice President, Technology, Alstom UK Ltd**

Thank you for your letter of 15 December 1998 regarding the above enquiry and the Memorandum we submitted in March.

We do not wish to offer supplementary information to that already submitted. However, it may be worthwhile noting that the name and status of our company has changed following our flotation in June last year. We are now a French registered company called ALSTOM and have acquired the electrical contracting and process control businesses of Cegelec. The company now employs over 110,000 people and has a turnover of around £10 billion. As the Committee may wish to be aware of that I attach a revised introductory paragraph to the original Memorandum. (See Annex).

Thank you for giving us this opportunity and I look forward to the conclusions of the enquiry.

*4 January 1998*

**Annex**

**The Engineering and Physical Sciences Based Innovation Enquiry Revision of Memorandum by GEC Alsthom Limited (Now Alstom)**

INTRODUCTION

1. Alstom UK Ltd is the UK operation of the Alstom Group which develops, designs and manufactures advanced equipment and systems for the electricity supply, rail transport and process control industries together with the associated contracting business. Worldwide, the Group employs (1998-1999) over 110,000 people and has a turnover of around £10 billion. In the UK it has approximately 22,500 employees, a turnover of £1.8 billion and undertakes at specialist research centres at Stafford, Lincoln and Whetstone an important part of the Group's total world-wide R&D activity of some £300 million annually. In the last 10 years its markets have been transformed due to progressive introduction of competition amongst its previously national monopoly customers. It now competes internationally against a small number of powerful multinational competitors on the basis of product performance, cost, and commercial offer.

## APPENDIX 4

**Memorandum submitted by Apax Partners & Co Ventures Ltd**

INTRODUCTION

1. Apax Partners provides private equity funding, corporate finance advice and asset management to entrepreneurial businesses internationally. We are one of the largest private equity organisations operating from 12 offices, across Europe, the US, Israel and Japan, and managing or advising private equity funds with capital totalling about £3·5 billion at current exchange rates. These funds are provided by many of the world's leading institutional investors through 27 funds and they are currently invested in over 150 companies. UK funds under management exceed £2 billion.

SUMMARY

2. We believe that several factors mentioned in your terms of reference influence companies in the field of engineering and physical sciences when deciding on developing new products and processes. In particular, we have some suggestions with regard to:

— Tax incentives for entrepreneurs (reduction in CGT and taxation on stock options).

— Effective stock markets for growth companies (support for EASDAQ, the European Association of Securities Dealers and Automated Quotations; extension of the AIM relief, including rollover relief, to smaller listed companies with market capitalisations of £50 million or less; support for the EC's "IPO Europe" initiative to facilitate equity offerings across the whole of the EC; and removal of the current anomaly which favours raising debt rather than equity by allowing debt-raising expenses to be deducted against corporation tax but making equity-raising expenses non-deductible).

— The funding of hi-tec businesses (replicate the US's SBIR programme; introduce grants to equip university labs; set up incubators; provide R&D grants to fund scientists carrying out research with commercial applications; encourage creation of "technology clusters" and easing of planning restrictions for them).

3. The Government must recognise the importance of successful entrepreneurship. The result will not only be the creation of successful role models of quality growth companies but also the encouragement of an entrepreneurial "can-do" culture where commercial success is admired, not envied, and where failure is forgiven as part of the entrepreneurial process of trial and error.

EVIDENCE

4. In the US, growth companies are the engine of future wealth and employment creation throughout the economy. They should be the same in the UK, but in order to achieve this, and to build on the UK's strong base in science, technology and creativity, they and those who invest and work in them must be given the right environment for risk-taking and reward.

*Taxation*

5. The most effective step that this Government can take towards improving the entrepreneurial environment is a reduction in Capital Gains Tax. For long-term investors in high-risk companies, the current rate of 40 per cent is too high and acts as a disincentive to make adequate funds available on the right terms

to entrepreneurs. Entrepreneurship is thus constrained and promising research and development is left unfinanced or exploited outside the UK under more favourable tax regimes.

6. There is a strong case in the UK for a lower overall rate of CGT, initially at 20 per cent, for investments held for three years or more. There is also a very strong case to apply such a rate without the complexities of tapering or qualifying periods. In the US, the substantial reductions in CGT at the end of the 1970s helped to ensure a greatly increased inflow of capital into smaller companies precisely because they created a powerful tax incentive for entrepreneurs and investors alike to become involved with illiquid, long-term investment in high-risk growth companies.

7. In the US, the CGT tax incentives have engendered a virtuous circle of risk-taking, wealth creation and reinvestment of capital gains in new ventures, which we see today in Silicon Valley and elsewhere. In 1997, to give a further impetus to this process, which helped create 65 million jobs in the period 1980-1995 while 42 million jobs were lost by mature companies, the US has again reduced the general rate of CGT, from 28 per cent to 20 per cent, and that for investments held for more than five years in companies with assets of up to $50 million has been reduced to only 14 per cent.

8. This contrasts with a US federal income tax rate of 40 per cent. The US has, clearly, found that the benefit to its economy and the gain to its Revenue over the life of the firms created and developed overshadows any possible leakage from tax avoidance.

9. A similarly bold reduction of CGT by this Government would have a powerful impact on UK small company creation and growth, including the creation and growth of "tech-stars". We recommend a simple reduction to 20 per cent on investments held for three years or more.

10. Another area of taxation which should be addressed by the Government is that governing stock options over shares in smaller companies. For the same reasons, we recommend that all gains on options held for three years or more by employees be treated as capital rather than income, and that the rate of CGT be reduced and the structure simplified by removing the complicated indexation rules. We recommend that for future grants of options, the CGT rate of 20 per cent apply for stock options exercised after three years or more over the shares of companies less than five years old and with assets of £30 million or less.

11. The Government should recognise that our tax environment for long-term high-risk capital has to be competitive with the US if we are to develop in the UK the technologies and managerial skills we need to fulfil our economic aspirations.

*Effective stock markets for growth companies*

12. One of the reasons for low levels of investment in early stage growth companies in the UK and more generally in Europe is the failure of the European financial system. Growth companies need to be able to access the public equity markets in order to obtain finance when the venture capitalist leaves off. For the venture capital industry is merely one part of the system. The system involves taking illiquid and "patient" money, in the main from pension funds and insurance companies, and backing new businesses. As these businesses grow, they consume increasing amounts of cash. And the ability of venture capital funds to provide funds to finance their growth is necessarily limited, while the cost of venture capital finance is higher than that of equity raised through the stockmarket. So, once the risk of the venture has fallen sufficiently and its potential can be better measured, the venture capitalist needs to be able to float promising companies on a stockmarket and raise much larger amounts of money from a wider group of investors at a relatively lower cost. One consequence of a successful flotation is that the company's progress will then be reflected in an attractive valuation which will give comfort to the initial shareholders, including the venture capitalist and investors in the venture capital fund. These investors will then be encouraged to recycle any distribution they receive and to increase the allocation they make to venture capital.

13. US venture capitalists will confirm that NASDAQ has been and still is absolutely essential to the development of the US venture capital industry, and that its effectiveness as a stockmarket for growth companies has attracted investment into venture capital funds specialising in early stage investment. NASDAQ has developed into a powerful stockmarket for growth companies because it has set out to specialise in them and to be highly regulated against fraud but not against business risk. It has a clear entrepreneurial identity which appeals to managers of entrepreneurial companies, and so attracts new companies as new technologies evolve. And it is managed independently of the NYSE and the American Stock Exchange, which concentrate on larger, more stable companies.

14. As a result, NASDAQ has led to the creation or development of new investment banks and market makers such as Robertson Stephens, Hambrecht & Quist, Alex Brown, Montgomery Securities and Cowen & Co., which specialise in growth companies and which realise that the less profitable a company is, the more investors need full and frequent disclosure about its prospects. These investment banks have assembled powerful analysts specialising in growth areas such as telecoms, biotech, information technology and media who continually monitor companies and keep the public and the investment community well informed about them. NASDAQ has also led to the creation of a multitude of specialist investment funds which focus on every type of growth company listed on NASDAQ. All of this creates liquidity for the shares of NASDAQ quoted companies.

15. The UK and more generally Europe also need a stockmarket specialising in growth companies in order to encourage early stage investment. We need an effective pan-European market modelled on NASDAQ which channels funds from European and US investors to European growth companies. This is why EASDAQ (European Association of Securities Dealers and Automated Quotations) has been set up.

16. EASDAQ has developed, with the help of NASDAQ, as an independent exchange backed by 93 prominent institutional investors, bankers and venture capitalists from the UK, Continental Europe, Israel and the USA. EASDAQ's focus is on European growth companies with international aspirations. EASDAQ has offices in Brussels, London, Frankfurt and Paris. In order to maximise liquidity, it has concentrated on companies with a market capitalisation of $100 million or more. To provide companies with maximum flexibility, it has made it easy to obtain either a single listing on EASDAQ or a dual listing on EASDAQ and NASDAQ, thus enabling growth companies with international aspirations to access both the US and European public equity markets.

17. Support should therefore be given to EASDAQ, as a pan-European stock market capable of playing a similar role to that of NASDAQ in the US. After all, it is thanks to this system that sectors such as semi-conductors, personal computers, biotechnology and the Internet have been financed in the USA, including companies like Intel, Apple and Genentech.

18. In the UK, further support should be shown by extending the AIM relief, including rollover relief, to smaller listed companies with market capitalisations of £50 millon or less. The Government should also support the EC's "IPO Europe" initiative to facilitate equity offerings across the whole of the EC and the Government should remove the current anomaly which favours raising debt rather than equity by allowing debt-raising expenses to be deducted against corporation tax but making equity-raising expenses non-deductible.

*Importance of hi-tec funding*

19. The third key area of support for the creation of growth companies is the provision of funding for hi-tec companies. Again, we can learn from the US where the Government has initiated the Small Business Innovation Research programme, the purpose of which is to create new technologies that offer solutions to the nation's most pressing scientific and engineering problems. In 1998, the Federal SBIR programme will fund more than $1 billion in early-stage R&D projects at small hi-tech firms—projects with the potential for commercialisation in private and government-sector markets. Small businesses (500 or fewer employees), as well as individual entrepreneurs seeking to start a small business, are eligible to apply.

20. We recommend replicating the SBIR in the UK, and allocating 2 per cent of the annual government research institutions' spending to grants for high R&D commercial projects. Other recommendations are to introduce grants to equip university labs, to set up incubators, and to provide R&D grants to fund scientists carrying out research with commercial applications.

21. Hi-tec growth companies are best created through "technology clusters". Several examples exist both within the UK and Continental Europe. In the UK, there are specialisations in IT in Cambridge, in semi-conductors in Glenrothes, in man/machine interface in Leicester and in software in the Thames Valley. In Continental Europe, there are specialisations in software in Louvain (Belgium), in IT and Biotech in Sofia Antipolis (France) and in Biotech in Heidelberg (Germany). A technology cluster requires a concentration of a higher centre of learning and/or a Government research establishment, a science park together with a reasonable quality of life environment, effective incubators and the availability of finance through angels, seed finance or venture capital. This concentration leads to a crystallisation of important networks (scientific, sub-contracting, social, technical, managerial and financial), all of which in turn help to create successful role models and a "can-do" culture.

22. Support should be given for the establishment of such technology clusters, and we should ease the planning restrictions for them to be located near universities.

*23 February 1998*

## APPENDIX 5

### Memorandum submitted by the Association of Independent Research and Technology Organisations (AIRTO)

INTRODUCTION

AIRTO is one of the largest communities of independent Research and Technology Organisations (RTOs) in Europe. It embraces 45 companies which employ some 8,000 scientists and engineers with a combined annual turnover approaching £500 million.

SUMMARY

1. For the UK to prosper and attain enhanced social objectives—eg improved healthcare, better educational facilities etc—greater awareness must be achieved among management of the contribution of science, engineering and technology (SET). The issue is a long-standing cultural problem. It will be cured only by a long-term consistent policy led by government and focused through education. The White Paper "Realising our Potential" was an excellent start but it requires a policy for strategic continuity by all administrations.

2. Government schemes in support of innovation and technology transfer require comprehensive review. A new approach should be based on developing past best practice, eg PTP and Carrier Programmes. As funds are limited, focusing on a limited number of key issues will be critical to success. The role of intermediaries has been ignored in recent years, this requires reassessment.

3. Attempts to create demand-side drivers for schemes related to innovation and technology transfer are sound in principle but have not been implemented successfully. Creating a demand market for technology transfer leading to innovation is a complex subject. Exploring the mechanisms which will create a demand market for knowledge transfer should be a consultative priority for government. AIRTO has presented a paper on this subject to the Minister for Science, Energy and Industry.

4. Foresight is an essential strategic tool for government and industry, in pursuit of enhanced technology transfer and innovation which leads to improved competitiveness. Increased resources should be allocated to Foresight in the OST. Foresight should be used as the accountability measure for all government departmental industry support programmes. The mechanisms for Foresight implementation require further investigation, support and development. Choosing Foresight priorities, through expert consensus and OST leadership, will be essential if critical mass is to be attained in initiatives which change UK culture in industry as it relates to innovation and SET.

MEMORANDUM

1. *Company decisions on developing new products and processes*

The methodology of decision making related to new products and processes will vary widely depending on the sector in which the company operates, its size and infrastructure, the maturity of the business and the company culture. Attitudes will be influenced by the approach to risk and cost cutting versus innovative investment.

The ESRC Centre for Research on Innovation and Competition[2] has revealed important variation in attitudes towards innovation between British owned companies and foreign owned companies resident in the UK. Many other references in the literature confirm that attitudinal postures towards risk influence strongly the decision making process. Notable contributions on this subject have been made by Dr P Ranganath Nayak and Dr John M Ketteringham of Arthur D Little in their book entitled "Breakthroughs" and a more recent contribution by Peter L Bernstein in his book "Against the Gods".

Research at Templeton College Oxford has described entrepreneurial enterprise in the UK, but little of that enterprise is related to engineering and physical sciences based innovation. This reflects the continuing paucity in the UK of engineers and scientists exercising leadership roles in national strategy for manufacturing, for harnessing technology in the pursuit of wealth creation and for changing the UK culture—including that of government departments. Prime Minister Thatcher's administration readjusted the balance of power between organised labour and management. What it—and all administrations—have failed to achieve is filling the vacuum in management for technology leadership.

Attempts by government departments to take a "promotional" approach to solving this problem, eg the Department of Enterprise campaign and the SET Week programmes, are superficial and will not resolve a deep-seated cultural impediment to commitment to innovation and technology transfer in industry.

The recent difficulties which Foresight has experienced in penetrating the Boardroom is indicative of the problem. The solution must be sought and found in the education system. By definition, that solution will be long-term. Even if started today, it will not yield results earlier than 15-20 years hence. It should head the agenda for all administrations and all Parliamentarians.

Without such commitment to a change in industry culture the UK will continue its long-term decline in wealth creation.

2. *Government schemes designed to promote collaboration*

Take up of research partnership with industry has become more difficult with industrial decentralisation, (smaller business units, reduced central R&D/engineering to act as receptors/translators). Much recent government policy has focused on links between industry and academia, with scant regard for intermediaries. There is a stark difference between the DTI and the Research Councils in commitment to new or existing

[2] Discussion Paper Number 8, January 1998.

initiatives for innovation funding (eg Faraday, Postgraduate Training Programme). DTI schemes with the purpose of nurturing partnerships (between a recipient company, an academic institution and an intermediary) appear to have been poorly planned, are unrealistic in incentive or dogged by interminable delays (eg Carrier Programme). Both the Postgraduate Training Programme (PTP) and the Carrier Programme have been spectacularly successful. Both exceeded all success criteria set for them. In spite of this success and the obvious way forward which they illustrate, the DTI has abandoned the Carrier concept and appears unable to give adequate resource support to the continuation and extension of the PTP.

Government innovation and technology transfer support schemes—as manifest by the DTI programmes—seem to have shifted towards the concept of "Challenge Funding" and support to Business Links.

At the outset of Business Links, AIRTO predicted they would be unable to make significant contribution to innovation and technology transfer. Business Links do provide useful service in upgrading low level business competences in SMEs. However, their contribution to the key issue of stimulating innovation and technology transfer in UK industry is minimal.

The concept of Challenge Funding is sound in increasing the influence of the demand-side. However, when Challenge Funding is spread thin and wide without any strategic purpose, it fails to make effective use of taxpayers' money. This has been the case with some Challenge Funding. It should be remedied by fewer projects of larger size and consistently linked to Foresight priorities. All programmes aimed at supporting innovation and technology transfer—including participation in European Commission programmes—need intermediaries to formulate projects and to provide knowledge translation expertise between the parties. In recent years the need for such facilitation has been ignored in much DTI policy. Progress in technology transfer for the purpose of innovation will not be achieved until that failure is remedied.

Appendix 2[3] and Appendix 3[4] of this Memorandum are AIRTO reports on the success of the Carrier Programme and the Postgraduate Training Programme.

3. *Creating a market for innovation and technology transfer*

Well managed companies recognise the contribution of innovation and technology transfer to profitability. Of their own volition they will utilise primary knowledge sources for technology transfer. However, many companies (large and medium sized) do not have this characteristic. Yet it is in the interests of the economy that such companies be encouraged to upgrade their performance. It is a market failure. This requires what AIRTO has described as "mission-driven change". It requires intervention to overcome market failure and to make a short-term contribution to culture change which increases the demand for inputs to action technology transfer. AIRTO has provided a report on this subject to the Minister for Science, Energy and Industry. It is attached as Appendix 4[5] to this Memorandum.

The business support infrastructure to innovation and technology transfer in the UK has developed randomly. Most of the schemes introduced by government have their origins in a valid objective. Few have real measures of success based on the achievement of measurable national objectives that relate to wealth creation and competitiveness. Some have been postulated on a false hypothesis, particularly as it relates to the innovation process. There is a lack of coherence between schemes, both across the departments of government and sometimes within a single department. The case for a comprehensive review is overwhelming.

4. *Foresight*

From the outset AIRTO has supported Foresight. Foresight is the essential strategic tool through which to set objectives agreed by industry, the intermediate agencies (RTOs), academia and government. Foresight is the means by which government may be informed in developing policy on innovation and technology transfer. Also it is a key tool for the development of synergy between UK initiatives and the Framework Programmes of the European Commission, thus ensuring leverage in the Member States. AIRTO applauds the work of Minister John Battle in this area and the support given to Foresight by the President of the Board of Trade to increase its influence in all departments of government. AIRTO concurs with the view of the Parliamentary Office for Science and Technology (POST) on the subject of Foresight.

The UK has a world-class science, engineering and technology (SET) base. The issue is how to steer the work of that SET base towards priority topics formulated through Foresight. At the same time mechanisms to achieve transfer of knowledge to companies from HEIs, both in the UK and worldwide, must be put in place. AIRTO suggests that the Carrier Programme, the PTP Programme, Faraday Partnerships and some of the previous programmes, which stimulated enterprise and partnerships, should be examined from which to design better programmes for the future.

In the past, the DTI and other departments' programmes for business support to innovation and technology transfer have failed through over-prescription. In pursuit of accountability, sometimes

[3] *Not printed.*
[4] *Not printed.*
[5] *Not printed.*

bureaucracy has become more important than the result. The worst example was the "away-from-the-market" prescriptiveness of DTI programmes for industry collaborative research. Foresight and future programmes must not become a victim of such bureaucracy.

Implementing Foresight themes and embedding new ideas in industry needs management by technology transfer agents. It is critical that the commitment of industry be won to the ongoing use of Foresight. The AIRTO recommendations for the continued development of Foresight, after its initial successes, are contained in the attached Appendix 4[6] which is the AIRTO recommendation to Minister Battle.

## APPENDIX 6

### Memorandum submitted by Barclays Plc

1. We have restricted our comments to the provision of finance aspects of the inquiry. It is important to distinguish between the financing requirements of a business undertaking research & development and one which is at the stage of taking a new product to a well researched market.

2. Where the latter is concerned, we would look to provide working capital finance, alongside any specific asset finance in accordance with standard criteria.

3. Where funding is required to research and develop a new product this is most appropriately served by the re-investment of surpluses from existing activities or from additional equity capital.

4. The banks' role in facilitating access to available equity through either their own venture capital providers or external "business angels" and venture capital trusts is critical.

5. Our research indicates that our customers have a strong preference for locally-based, experienced managers who can provide expert advice. Therefore, within Barclays, we are shortly to launch innovation Centres of Excellence in key locations where we have strong connections with not only equity providers, but also with University research facilities, Science Parks, Business Incubators and Business Links.

6. The establishment of a national business angel network to provide easy access to the wealth of potential investors will provide an important addition to this service.

7. We are also currently reviewing our range of product and service offerings to Innovation customers.

*9 March 1998*

## APPENDIX 7

### Memorandum submitted by the Birmingham Centre of Manufacturing Ltd

1. Introduction

The Birmingham Centre for Manufacturing (BCM) is a partnership organisation owned by the Birmingham City Council, Birmingham and Solihull Training and Enterprise Council and University of Central England. The BCM has been in operation for 14 years and in that time has dealt with over 1,500 Small and Medium enterprises. The mission of the BCM is to give specialist support and assist manufacturing companies and people within the West Midlands to achieve "World Class" standards, and to encourage economic growth through manufacturing. The BCM provides training at all levels in manufacturing techniques, from unemployed people through to senior managers and provides consultancy for companies to enable them to develop both their strategic aims and their day to day running and use of modern techniques. Each year the BCM will deal with up to 500 SMEs in the West Midlands and will support them in a number of different initiatives.

2. The Needs of the SME

Most SMEs are not good at accessing any government of European funding and tend not to have the expertise to understand the bureaucracy that goes with it. They would say that they have no time in which to work with initiatives and much of the funding available is very difficult to "sell" to the SME, as what they really require is often slightly different from the prescriptive way the funding is accessed.

The BCM has found over the years that whilst there are a small number of companies that wish to grow and improve there are still a large number of SMEs that do not realise the pressures that will come upon them and seem very content in their present situation. These companies are often in a niche environment and have quite loyal customers, and often a small customer base of perhaps one or two customers making up 85 per cent of their total turnover.

What the SMEs first require is inspiration, and if innovation is to become the key they need to be then inspired to innovate both their processes as well as their products. Much of the research done at the BCM

[6] *Not printed.*

has shown that many of the companies that do grow, grow through opportunity and not innovation in new products. This requires a different form of innovation and a different set of skills in order to drive the company forward. Without the inspiration to do this the companies will not find the will to succeed.

SMEs also require a "fire break" to enable them to do something, and even those willing to take risks will not be able to unless techniques or funding can be found to give them an opportunity to move to the next stage. As SMEs grow they become busy and the risk involved in innovating or going to the next stage of growth is quite considerable, so many companies stop at this stage. The SMEs also require local centres of excellence, which have real creditability in both their techniques and the local community. The way SMEs use innovation and grow is through winning the hearts and minds not just of the key managers but also of the workforce itself, and companies enabling their workforce to be empowered to use their ideas and skills to grow the business.

In terms of funding this requires a flexibility and fast access that often the bureaucracy legislates against. There is also a move recently to more output based funding and whilst this will help companies to grow the skills of their people, it will not help them innovate and grow the company. Those successful companies that the BCM have worked with (and there will be nearly a 100 of these) will be doing different things across the whole company and require a more flexible and less prescriptive regime to help drive that forward.

Another area that has become very common in the companies that BCM work with is the need for real ownership and drive, and inspired leaders who will actually take the company forward. Through networks and benchmarking, and visits to other countries to see how SMEs grow there, the BCM has enabled many companies to see role models that suit their environment. The use of very large companies and of typically Japanese automotive manufacturers as role models have never really worked, although obviously the techniques they used have. However, the use of SMEs in other countries who face similar problems but have found unique and innovative ways around those problems is often enough to inspire the leaders of SMEs to take their company forward.

The final part of innovation as we see it is developing team business skills (eg Marketing, Computer Systems, Continuous Improvement etc) and beginning to work with their own suppliers and their customers in partnership. Much of the present climate does not expose senior managers to these business skills and there is a growing need for people at all levels to understand the impact their decisions have right across the business. This will also include developing the business skills of the shop floor as well as their technical skills and under the banner of Investors in People or NVQ qualification, the drive to educate and train the workforce is going well.

3. CONCLUSION

The BCM has considerable experience in working with SMEs, and with enabling them and supporting them in their growth and innovation. We believe we are the largest centre of excellence in the UK and that we have worked with more SMEs than any other centre of excellence in the UK. The difficulty is always the start of getting companies to be innovative and drive up the skill levels of all their people.

In the end it is very rarely funding that drives this; however, it needs to be available to support the drive. What is required is a systematic approach through networking and through company visits to inspire SMEs to do new things. Once inspired they need tremendous resource and support in order to enable them to grow. We at the BCM concentrate on the quality of companies and not quantity, and much of the funding available has targets which have to do with quantity and not with quality. Growing a small number of SMEs considerably will have far more impact than just slightly working with a great number of SMEs (where the grass will quickly grow over those areas that have been improved). In conclusion the BCM believes it is important to deal with companies holistically and much of the present aim of innovation seems to be in very specific areas. Companies that grow effectively tend to find their innovation through a number of different areas and need a much broader creditable and flexible approach.

*27 April 1998*

## APPENDIX 8

### Memorandum submitted by Bookham Technology Ltd

INTRODUCTION

1. Bookham Technology Ltd is a current and recent participant in Government funded and Government sponsored innovation projects. As a participant in the LINK scheme with projects including OPTIM, SHODOS and FLAPS the Science and Technology Committee requested a memorandum addressing several points, which are detailed below.

1(a) *How Bookham first learnt about LINK*

2. Dr Andrew Rickman formed Bookham Technology Ltd in 1989, with the aim of developing the production of integrated optical circuits. During the initial phase the company received funding from various sources, including the SMART programme. From the SMART programme Bookham was made aware of LINK projects through discussions with the DTI. They explained that LINK projects would provide a route to business opportunities. In Bookham's instance this was for the development of optical components and structures for automotive sensing applications in the OPTIM project.

1(b) *The reasons Bookham decided to participate*

3. As a start-up company, the initial reason for Bookham to participate in a LINK project was for the external monetary contribution, which was a vital asset to Bookham allow it develop its technology. In addition to this, the LINK projects provided an enlargement in Bookham's knowledge base by providing a suitable range of partners to form the consortium. The introduction of Bookham to these partners opened additional markets for sensor developed by Bookham, (for example automotive and aerospace markets with the OPTIM and FLAPS projects respectively). In addition to this, the government funded nature of DTI projects meant that there was a reduced risk for Bookham to undertake the development of new products and improve its product base.

1(c) *Ease of initial participation*

4. The initial participation in the LINK project was felt to be hard. The drafting of the LINK proposal was found to be complex because addressing the correct level of technical detail and organising work-packages that included other companies within the LINK consortium was time-consuming and complex. However, excellent supervision and guidance was provided by the DTI to overcome these difficulties.

(2) *Whether involvement in LINK met Bookham's objectives*

5. Bookham's involvement in the LINK met all of the objectives. It helped Bookham to develop a new technology with the required financial and technical support. In addition to this it provided less visible advantages including industry access, application driven projects and promoted Bookham to the technical and industrial community.

(3) *The impact that LINK has had on Bookham*

6. Bookham's first LINK project was OPTIM, which was completed at the end of 1997. This was a technically risky project, but this risk was significantly reduced by the commercial and technical involvement of Ford Motor Company and the DTI. The development project provided Bookham with a successful demonstrator system. With the foundations provided by the LINK project, Bookham is now working with an automotive company to further the development to a production system.

(4) *Any barriers that have prevented Bookham gaining more from LINK*

7. No barriers prevented Bookham from gaining more from LINK.

(5) *Overall assessment of the scheme*

8. In conclusion, LINK has assisted in the development of Bookham's sensor products, which are in a market of significant importance for the UK, and provided routes to additional world-wide sensor markets. Bookham believes that LINK projects are essential for many British start-up companies looking for financial and technical assistance to develop an application driven product suitable for the world markets.

OTHER ITEMS

9. Bookham would be happy to provide a witness to discuss the operation and effectiveness of LINK in relation to Bookham Technology Ltd.

*15 February 1999*

## APPENDIX 9

### Memorandum submitted by the Bristol Colloid Centre, School of Chemistry, University of Bristol

INTRODUCTION

The Bristol Colloid Centre (BCC) is an industrial consultancy organisation operating from within the School of Chemistry at the University of Bristol. It was established by academics working in the field of colloid science[7] with the overall objective "to add value to industrial research and technology by effective transfer of colloid science knowledge". Through the use of short courses, one day awareness forum, and contract consultancy and research it has acted as a facilitator for the flow of colloid science knowledge into industry. Its most recent awareness forum (May 1998) was attended by 90 delegates from 48 companies, 20 of which were SMEs. Also since its inception in 1993 the BCC has had contact with approximately 220 UK companies, where about 100 of these companies are SMEs. The BCC has recently received funding from the DTI (£132,000 over 12 months) to evaluate the effectiveness of the technology transfer process, using colloid science as the enabling science and two sectors of industry (pigments and dyes and paints, coatings and inks). This programme was started in February of 1998.

Since the BCC is contained within a university department, and interacts with over 200 UK based companies, it is ideally placed to comment on the flow of knowledge from academia into the industrial sector. The comments made are specifically relevant to the area of general coatings technology, but could be applied to many other areas of industry.

EVIDENCE

1. *The development of new products is often not driven by the manufacturing company*

Companies that manufacture coatings materials are very often REACTIVE rather than PROACTIVE. They are often reacting to, for example: environmental legislation (phasing out of chemicals); raw material shortage; customer feedback (superior performance of competitor product, change of process conditions); and raw material supplier information (improved performance of new material).

2. *Product innovation is often driven by component suppliers*

Suppliers of formulation components need to be at the forefront of their technology, both in terms of awareness and development. They are continually trying to replace their competitor's product with their own in a manufacturer's formulation. As a result they are always looking for a novel technical edge to their product. Product manufacturers tend to use their own resource to: (a) protect their core business through their IPR and patenting; and (b) evaluate the relative performance of their competitors' products.

3. *Product invention is rarely an output from an academic research programme*

Academic research programmes are designed to give training in defining and solving problems. This is achieved through personnel development (interpersonal and communication skills), and the utilisation of available research techniques. This process should be the supply chain for the drivers for product innovation, ie the suppliers.

4. The problem of Technology Transfer is one which is solved through the provision of Technology Access. This provision is supplied at a number of different levels:

- flow of undergraduate students into industry;
- flow of postgraduate students into industry;
- student interaction between industry and academia through, for example, CASE and industrial CASE studentships;
- interaction between industry and academia through consultancy—often industry supply the product knowledge, while the academic input is one of measuring techniques; and
- attendance by industrial personnel at conferences, awareness forums and training courses.

5. The provision may be categorised at two distinct levels: the supply of trained personnel into industry through graduate and postgraduate study; and the supply of a platform for continuous "in-service" training (of both individuals and companies). The former is addressed very successfully in the current higher education system. However, the "in-service" training provision has seemed to lack cohesion, and connectivity to the primary provision.

6. The BCC has attempted to develop a platform for raising the level of knowledge of modern technology through its Short Courses and Awareness Forum. Based on attendance numbers (individual and company),

[7] Colloid science underpins much of the product manufacturing industry in the UK, including paints and coatings, inks, dyes, food, pharmaceuticals, personal care, household products, construction.

these appear to be very successful. However the problem of connectivity needs to be addressed, and the answer may already have been initiated in the form of the Faraday Centres. It should be possible to utilise this type of partnership to bring together the facilitators in higher education institutes (ie the academics) and the perceived facilitators in industry (ie the suppliers) to drive through the technology transfer. The access to this technology would be provided by:

— Awareness Forum—a theme is identified for a one day seminar, which encourages cross fertilisation of ideas between different sectors of industry;

— Short Courses—broad knowledge based courses and industry specific courses should be provided, which are accredited through, for example, the Royal Society of Chemistry;

— Masters Courses—these courses should be designed (or re-designed) using the industrial facilitators, in line with the new EPSRC initiative;

— Information Networks—a central information network should be provided through use of the internet incorporating a database of academic expertise in colloid science; and

— Seed research—short-term seeding research and development (consultancy) programmes should be provided, with particular emphasis on the involvement of growth SMEs.

## APPENDIX 10

### Supplementary Memorandum submitted by British Aerospace plc

This note is supplementary to the evidence given to the Committee by Mr John Weston and Mr Trevor Truman 2 December 1998.

RESEARCH & DEVELOPMENT EXPENDITURE:

The questions concerned the amount of Research and Development conducted by the Company, the percentage that this represented in relation to sales and the amount of this funded by the Company.

1. Some brief definitions are necessary: within the Company we allocate our costs as follows:

(a) Research: Technical work in support of a future capability which is not specific to a product.

(b) Development: Technical work that is specific to a product and needs to be done to realise the product performance.

These costs can be either:

(i) Company funded (Research or/and Development) work is a part of the cost of the operations and will impact the profitability of the Company . . . or . . .

(ii) Customer Funded work (Research and/or Development) is funded under contract with our customer and is not therefore a burden on company profitability.

2. As reported earlier to the Committee we do not target particular percentages of R&D work. Each business and each project is assessed for the work that will be needed to bring projects to fruition and to create new capabilities. These are reviewed and assessed within Company procedures and form part of the business planning process. Within this process there is scope for adjustment. Areas of potential synergy and duplication are examined and opportunities are taken for collaborative work between businesses and between BAe and other parties where it will be beneficial to do so.

3. When considering the level of R&D support to the total sales of our business we must bear in mind the nature of the customers' requirements. The costs of developing a project such as Typhoon are such that no nation, let alone a single company, can afford to finance them. On major defence projects our customers identify the cost of R&D (especially development) and pay for it separately, this also allows the customer to specify the exact capabilities of the product. All development, whether paid for by the customer or the company, is relevant to the total sales of the company. (It is on these grounds that we disagree with the view taken by the DTI R&D Scoreboard which looks to include only Company funded R&D—we think that if all the sales are relevant then all of the associated R&D must be included).

4. British Aerospace is a diverse business: much of what we do is by way of being a Prime Contractor—taking responsibility for supplying products and services whether or not we ourselves design or make the whole content. Some of our business has no need for us to conduct R&D—examples are some types of consultancy services, aircraft leasing, maintenance resources, factoring and others. We estimate that such businesses accounted for about £2 billion of our turnover in 1997 which was, in total, £8.5 billion.

5. In the area of business where R&D is relevant much of the R&D is conducted by our suppliers who can typically account for about 65 per cent of our sales in relevant areas. Some of this effort by suppliers is, of course, influenced by R&D work done in BAe.

6. Although we do not routinely account for our businesses in this way we estimate that, taking these issues together, the BAe sales which are directly or indirectly impacted by BAe R&D would be of the order of 50

per cent of total sales. By this measure our combined R&D activity approaching £500 million represents a little over 11 per cent of the related sales and is one measure of R&D intensity.

7. The Committee also wanted to understand how much Research was conducted by the Company. This is, of course, contained within the total for R&D and was, in 1997, £84 million nearly all of which was funded by the Company. This represents 1 per cent of gross sales for the Company but around 2 per cent of the narrower field of work to which the research applies.

8. Another measure of the level of R&D intensity of a company could be the percentage of staff employed who are devoted to product regeneration and improvement. By this measure British Aerospace employs about 25 per cent of its effort on these tasks in the relevant businesses.

9. The notes above have been confined to the arena of product regeneration and improvement. This is by no means the only area in which the Company invests in its own future with its own funds. We have major programmes of organisational and cultural change, of increasing the ability of our workforce through training, of generating new approaches to manufacturing management and by innovation across all areas of the Company's operations.

## The British Aerospace Virtual University

10. British Aerospace, in establishing its Virtual University, has underlined that education, training, research, technology and development of its people is at the core of its strategy for growth and international development. Announced in May 1997, the British Aerospace Virtual University is a business strategy built upon strategic partnerships with academe and enterprise. This connection of two normally separate cultures will link business needs to learning and research and will enable both the company and universities to benefit. The strongest motivation lies in preparing our people for the challenges and market evolution which lie ahead as the aerospace and defence sector consolidates and adopts a global business position. This sector still employs well over a million people world-wide and plays a vital role in the knowledge-driven economy, in innovation, and in engineering excellence.

11. The Virtual University has adopted an academic framework and has faculties for Learning, the International Business School, the Faculty of Engineering and Manufacturing Technology, the Benchmarking and Best Practice Centre, and the Sowerby Research Centre. These are supported by a company-wide infrastructure to support continued learning for all employees and, in the longer term, to offer services to the supplier chain, the customers, and the company's international partners. The Virtual University is based on partnership and collaboration with traditional universities, not on competition with them. Programmes will be delivered to our employees by partner institutions. Examples of initiatives of the Virtual University are outlined below.

12. The network of Learning Resource Centres across the company offers access to the company-wide "Learning and Development Guide" on Intranet, which guides employees through the programmes available, offers an assessment of learning styles and guidance on job profiles and career progression. Procedures are in place to link "learning" to the progression of careers or reward and recognition within the different workplaces, and measures of how effective such learning might be. We believe that these measures will contribute to our ability to allow the most talented people to realise their potential within the Company.

13. The Virtual University and our Sowerby Research Centre in 1998 founded, in collaboration with Rolls Royce, and the Universities of Cambridge, Southampton and Sheffield, an interdisciplinary University Technology Partnership. The five-year research project on Design and Manufacturing reflects the importance of design on every aspect from concept to the ultimate delivery of high performance and cost effective processes, systems or products.

14. British Aerospace has sponsored a Systems Engineering course at Loughborough University. Two classes have now graduated, 30 graduates in 1997 and 40 graduates in 1998 graduating from this jointly designed and developed Masters degree course. The majority returned to the company including seven former aircraft apprentices who have had the opportunity to develop their potential into more important roles on major systems integration projects in UK and Europe. This MEng course is open to other students and other companies, even though British Aerospace sponsored all the original development costs and supported the University's own expertise with equipment and lecturers.

15. In January 1999, the first cohort of the new Open University and Lancaster University Management Certificate began to study management for the 21st century in a co-designed programme that also includes some of the executive behavioural skills and team work that are central in a modern global organisation. Some 5,000 employees will undertake this programme over the coming years, and other companies and international partners have already shown interest in this innovative educational product.

British Aerospace Spending with Universities

16. Within the £485 million overall R&D spend reported by BAe for 1997, the Company spent £5 million with universities on technical and scientific work of which about £2.9 million was on research. The total expenditure on the technical, research, education, and personal development and learning activities with the Universities would be approximately £10 to £11 million per annum.

17. Over 50 per cent of this total investment is with six universities as major strategic partners in engineering and R&D. BAe invests over £25,000 per annum at each of 32 academic institutions from more than 70 with which we have sustained relationships.

18. BAe offers access to special R&D facilities to the external research community, such as wind tunnels, and supports 10 CASE industrial studentships per year, co-ordinated by the Sowerby Research Centre with the collaborating University. We are eligible for six DARPS (defence and aerospace research partnerships) in the EPSRC competition launched recently (arising from Foresight) out of the 10 initially submitted.

*18 February 1999*

## APPENDIX 11

### Memorandum submitted by the British Aerospace Virtual University

British Aerospace, in establishing its Virtual University, has underlined that education, training, research, technology and development of its people is at the core of its strategy for growth and international development. Announced in May 1977, the British Aerospace Virtual University is a business strategy built upon strategic partnerships with academe and enterprise. This connection of two normally separate cultures will link business needs to learning and research and will enable both the company and universities to benefit. The strongest motivation lies in preparing our people for the challenges and market evolution which lie ahead as the aerospace and defence sector consolidates and adopts a global business position. This sector still employs well over a million people world-wide and plays a vital role in the knowledge-driven economy, in innovation, and in engineering excellence.

The Virtual University has adopted an academic framework and has faculties for Learning, the International Business School, the Faculty of Engineering and Manufacturing Technology, the Benchmarking and Best Practice Centre, and the Sowerby Research Centre. These are supported by a company-wide infrastructure to support continued learning for all employees and, in the longer term, to offer services to the supplier chain, the customers, and the company's international partners. The Virtual University is based on partnership and collaboration with traditional universities, not on competition with them. Programmes will be delivered to our employees by partner institutions. Examples of initiatives of the Virtual University are outlined below.

The network of Learning Resource Centres across the company offers access to the company-wide "Learning and Development Guide" on Intranet, which guides employees through the programmes available, offers an assessment of learning styles and guidance on job profiles and career progression. Procedures are in to link "learning" to the progression of careers or reward and recognition within the different workplaces, and measures of how effective such learning might be. We believe that these measures will contribute to our ability to allow the most talented people to realise their potential within the Company.

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2. Over 50 per cent of this total investment is with six universities as major strategic partners in engineering and R&D. BAe invests over £25,000 per annum at each of 32 academic institutions from more than 70 with which we have relationships.

3. BAe offers access to special R&D facilities to the external research community, such as wind tunnels, and supports 10 CASE industrial studentships per year, co-ordinated by the Sowerby Research Centre with the collaborating University. We are eligible for six DARPS (defence and aerospace research partnerships) in the EPSRC competition launched recently (arising from Foresight) out of the 10 initially submitted.

*20 January 1999*

## APPENDIX 12

### Memorandum submitted by British Steel plc

Introduction

British Steel plc is the EU's largest manufacturer and distributor of steel. British Steel spent £45 million on research and development in 1996/7. The following outline memorandum responds to the terms of reference included in the letter of enquiry from the Science & Technology Committee dated 27 January 1998.

Memorandum

1. As an overall statement, British Steel's decisions on developing new products are not significantly influenced by the industrial application of Government funded research. However, the company would look to obtain such funding if there were a gap in fundamental understanding which needed to be bridged to facilitate the progress of a new product development. By the same token, British Steel would look to Government Laboratories to fill gaps in pre-competitive fundamental understanding (although the company would be more likely, given its field of operations, to work with a university).

2. British Steel's collaboration with universities has increased recently, based in part on the operation of Government schemes to promote such collaboration. The universities, in seeking such funding, have themselves moved towards research which is applicable to industry, and away from improving fundamental understanding. In pursuing the former the importance of the latter must not however be diminished; the UK needs to ensure that a deep rooted fundamental understanding of supporting science continues to be available from universities, its only source.

3. The protection of intellectual property rights is a major factor for British Steel in deciding whether R&D is done collaboratively or in house—and, for collaborative research, it also influences the choice of partner.

4. In British Steel's view the FORESIGHT Programme has been successful in establishing research priorities for UK plc, and in focusing university research in agreed directions, However, it does not appear to have had a significant impact on product development decisions by industry. At best, industry would expect that future focused themes, defined by the next FORESIGHT exercise, should reflect the anticipated trends in new products from industry.

5. Whilst the Engineering and Physical Sciences Research Council has been reasonably effective in fostering technology transfer, much of this is thought to be due to industry itself reaching in to take advantage of funding for collaborative work; this should therefore continue.

*18 March 1998*

## APPENDIX 13

### Memorandum submitted by the British Venture Capital Association

Introduction

The British Venture Capital Association (BVCA) represents virtually every major venture capital firm in the UK, which each year accounts for over 95 per cent of annual venture capital investment in the UK. The BVCA is dedicated to promoting the UK venture capital industry for the benefit of entrepreneurs, investors, venture capital practitioners and the economy as a whole. Through its members, the BVCA has an in depth knowledge of the issues affecting the wide range of high growth smaller and medium sized unquoted companies in which they invest.

### Summary of Recommendations

- Encourage the development of all seed capital funds, for example by subsidising a proportion of their due diligence, monitoring and employment costs or underwriting part of the financing risks (see 1.4).
- Encourage "career leapers"—experienced corporate managers—to move to young companies through tax incentives (see 1.5, 4.3 4.7).
- Bridge the gap with funding between technology discovery and "proof of utility"—potential commercialisation, reducing the obstacles to commercial investment (see 2.1).
- Improve university and business inter-communications (see 1.5, 2.2, 5.1).
- Investigate how intellectual copyrights and patent positions can be assessed as commercially viable (see 3.1).
- Encourage serial entrepreneurs possibly by way of tax incentives (4.3).
- Produce a scheme that encourages business angels, or simplify the Enterprise Investment Scheme, so that venture capital firms can more easily invest alongside business angels (see 4.4).
- Improve the small firms Loan Guarantee Scheme (see 4.5).
- Reduce the Capital Gains Tax regime for business angels (see 4.6).
- Improve share options for smaller unquoted companies (see 4.6).
- Create an equity guarantee scheme or soft loan scheme (see 4.6).
- Learn from the German and Israeli approach to technology companies.
- Encourage technical and corporate innovators from outside the UK to locate in the UK (4.10).
- Encourage UK technology companies to be globally competitive (see 4.11).
- Persuade the Engineering and Physical Sciences Research Council to allocate a part of its budget to the assessment of the commercial potential of technologies (see 6.1).

### Terms of Reference

To enquire into the manner in which companies in the fields of engineering and physical sciences decide on developing new products and processes and the factors influencing their decisions, with particular reference to:

1. *The industrial application of government funded research and the respective roles of government laboratories and independent research and technology organisations*

1.1 The traditional view has been that industry and academia do not communicate with each other very effectively. This now appears to be changing, in part because of universities' increasing needs to find alternative sources of finance to government funding and because of the increasing number of role models of successful companies started by academics or based on university research.

1.2 As the universities have begun to be more commercially orientated, it has become easier for the venture capital industry to start to fund science based companies coming out of these institutions, creating the start of a virtuous circle. Examples of new specialist firms and funds that have started up over the last year or so focusing on this sector include; Amadeus in Cambridge, UK Medical Ventures (a specialist fund created by The Medical Research Council to help exploit its technology, which has been heavily backed by 3i, a BVCA member) and Merlin Ventures (all except UK Medical Ventures are BVCA members).

1.3 Large companies have for some while been working alongside certain universities with some effect. The "gap" in exploitation would seem to be with the smaller more entrepreneurial UK companies. These companies have found it relatively hard to access the universities, lacking as they do the resources of the larger groups.

1.4 The amount of seed capital funding available via the venture capital industry has increased in recent years but it is still its least common type of funding. The difficulties arise largely in the level of management (and therefore cost) required for quite small amounts of initial investment. Venture capital firms are used to working with cost ratios of around 2 per cent of assets of the management, whereas with seed funds this ratio can often be of the order of 10 per cent. We would, however, like to see the encouragement of the development of all seed capital funds (perhaps by subsidising some of their due diligence, monitoring and employment costs or underwriting some of the financial risk).

1.5 Equally we would like to find ways of encouraging seasoned corporate managers to move to young companies ("career leapers"), perhaps through tax incentives such as the ability to write off capital invested against past or future income tax liabilities. We would like to find ways of better communication between educational establishments and the world of commerce. We believe that a closer dialogue between the educational system and the business community would improve the prospects of academic research being exploited commercially.

2. *The operation of government schemes designed to promote collaboration in and industrial application of research*

2.1 The government has long run successful schemes such as SMART and SPUR awards and we have anecdotal evidence of various research exploitation groups within universities regarding these as being of very significant importance. Government schemes, however, have typically focused on the creation/proof/concept of technology itself. It is our view that there is a lot of very interesting technology within UK academic institutions. The difficulty is now in the linkage between that environment and the commercial world. In particular, investors typically seek to back companies that have a clear commercialisation strategy and have capable management. Many of the interesting technologies evolved with government funding are left somewhat stranded before reaching these next two milestones. It would be particularly valuable to have some form of government scheme which bridged this gap and allowed people help, advice and funding to create outline commercialisation plans for interesting technologies. The objective of this would be to make the "hand over" of funding from commercial investment organisations easier. This is particularly relevant for small firms, whereas large firms may be able to afford the overhead of doing much of this work themselves. The "University Challenge" venture capital fund, appears to be an important contribution to this sector.

2.2 Many of the issues surrounding collaboration and the industrial application of research are cultural and educational. We should beware of quick fixes to long standing cultural problems but it would certainly be welcome to see a greater targeting of the creation of effective dialogue between academic institutions and the business community at all levels.

3. *Intellectual copyrights and patenting*

3.1 The key issue for investors here is the cost of due diligence to assess the status and effectiveness of intellectual copyrights and patent position of the companies they are considering investing in. In particular it is often very hard to place this information within a sensibly broad commercial context. In the UK there are only a few experienced "lead" venture capital investors in technology and we would be keen to find ways that we could encourage a greater depth of experience to be created. The funding required to employ more experienced investment executives is a serious problem for those firms with the small funds that typify much of the early stage technology funds in the UK.

4. *The provision of finance to support enterprises involved in the application of research and innovation*

4.1 Does the government have a cost benefit equation for job creation? It would be useful to know the answer to this if we are to work effectively towards a common solution.

4.2 The overall situation that we find is encouraging. The amount of venture capital invested in technology businesses has increased by 10 times from 1983 to 1996. It is also worth noting that over 70 per cent of UK biotechnology companies listed on the London Stock Exchange have benefited from venture capital funding.

4.3 Whilst the returns from technology investments in general can often be attractive to investors, there are a number of specific difficulties:

(i) The relatively low returns that can generally be achieved at the early stage or seed investment end of the market.

(ii) The difficulties faced by some venture capital firms that specialise in early stage technology investments in raising funds of a size that would enable them to afford to employ more experienced investment executives.

(iii) The lack of a sufficient number of experienced investors in the sector.

(iv) The poor quality of management in many potential investment opportunities.

4.3 The whole debate about providing finance to support technology has tended to miss one crucial point; it is that people are supported by the "investment community" rather than "technology" per se. In our view we do not see any specific shortage of "technology" in the UK but rather we see a shortage of seasoned managers who have the capability of building successful businesses. We do see a greater number of such "corporate innovators" in the UK than a decade ago. In our view this pool of people is as much a resource which the UK should foster, as is "technical innovation". Within this pool of people, the most important, and those who we would like to see encouraged further, are "the serial entrepreneurs"—people who have a track record of successfully starting companies. Persuading these people to focus their talent on young technology businesses, by whatever means, would be a very effective way of helping create successful businesses that people wish to fund with the depth of resource required for success. We believe that there could be room for tax incentives to encourage these individuals further.

4.4 We believe that there are also arguments for a simplified system of tax incentives for private investors in technology businesses. The Enterprise Investment Scheme may in part be aimed at this but, in our experience, its rules are complex and it tends to be difficult to accommodate alongside more conventional institutional capital.

4.5 Schemes, such as the small firms Loan Guarantee Scheme (LGS), have been very helpful in encouraging new businesses development. A survey conducted by 3i in 1994 showed that 38 per cent of the young companies it has backed had received an LGS loan. However, the DTI restricts the maximum loan for companies which have been trading for less than two years to only £100,000 compared to £250,000 for established businesses and its guarantee to 70 per cent rather than 80 per cent for established businesses from clearing banks. These loans, anecdotally, also seems to be less readily forthcoming for technology based businesses. We would encourage the DTI to consider whether it might be possible to allow younger companies to benefit from the full £250,000 limit; to find some way of targeting technology companies; and to consider whether a larger overall cap on the LGS loan than £250,000 would be an appropriate mechanism for helping smaller companies.

4.6 Overall it is the motivation of the people that is key and not the motivation of investors. In our view, the most effective investors tend to follow capable people and we would not wish to see a scenario whereby tax incentives for investors encouraged them to back people whose skills were only marginal, rather than focus resources on the most able. Getting the motivation right for individuals is in part about increasing the upside for them. This is about:

(i) Capital Gains Tax. Following the Budget, this situation has changed significantly in the entrepreneurs' and management teams' favour, however, the benefits for business angels need to be fully assessed. The financial rewards to individuals who invest in technology businesses usually come in the form of capital gains. Regardless of specific incentives, the rate of CGT is therefore likely to be very influential in determining an individual's appetite to invest.

(ii) Effective share option schemes should be available in a tax "friendly" way and we look forward to taking part in the discussions for smaller companies.

(iii) Potential for an equity guarantee scheme or soft loan schemes (as this in reality gives the individuals a bigger slice of the equity available in the companies).

4.7 Motivation is also about reducing the downside that individuals experience. We would be keen to encourage the more entrepreneurially minded middle and senior managers in large corporations to look at starting or being associated with smaller technology based companies. Key to this, we feel, is reducing the downside that they may experience. In our view many of these people could become involved in younger companies, would wish to, and would have a lot to contribute but are deterred by the risk involved. In particular we believe that they are influenced by the relatively high social stigma attached to corporate failure, which is greater in the UK than in the USA, as well as the financial risks involved. Working with large companies they are more capable of earning high salaries and have reasonable job security. They will usually have to forego both of these to start up a company and we would wish to see ways of lessening their perceived cost in doing so.

4.8 We believe that the whole of this issue of the creation and fostering of technology companies needs to be looked at in a far more global context than has occurred to date. For example, the continual comparisons between the US and the UK are, in our view, unhelpful and misleading, particularly as the cultural differences between the two countries are so large. The USA venture capital market has benefited from considerable government intervention over the past 15 years, it is also supported by a strong stock market (NASDAQ) with good investor demand for early stage technology companies that is not seen in the UK. In spite of this, in early stage to expanding companies, although the USA economy is some seven times the size of the UK's, in 1996 the UK made just over half as many investments as the USA in these types of companies. Relative to GDP, the UK invested about the same amount as the USA in 1996.

4.9 We would, however, like to see the debate moved towards what is happening in Germany and Israel, where start up technology companies receive a far greater level of financial support than in the UK. We are not advocating the large-scale government intervention that has been applied in Israel (successfully) but we do feel that these economies and cultures bear close comparison. In addition, as good ideas for start-up companies are pretty transportable and we have begun to notice one or two biotechnology start-up companies choosing Germany as a location over the UK, we believe that this comparison deserves more attention than it has been publicly receiving.

4.10 We need to recognise that markets for technology companies are international now. The UK's outlook should be similarly international if our native resources to be fully exploited. We should be concerned to retain our creative talent in the UK, both "technological innovators" and "corporate innovators", and to make the UK an attractive place for talent from other countries to locate. We believe that it is important to develop what we see as a scarce resource and encourage this talent to be "recycled" in new ventures wherever possible.

4.11 Because the competition for technology companies is increasingly global, we do not feel it is correct to focus simply on getting more businesses funded. They must be quality businesses that are globally competitive. If not, the long-term result will be to create a problem and disillusionment with technology in the UK.

4.12 Technology markets also develop quickly and speed in product development and establishing distribution channels is becoming extremely important. The sale of advanced technology companies is often,

mistakenly, seen as a bad thing for Britain. In fact it frequently represents the best way for technology to be fully exploited and returns capital to the UK which can be re-invested in other products.

4.13 Interestingly, we believe that one of the benefits of the growth in funding management buy outs by the UK venture capital industry is that a greater number of managers who would have traditionally remained within large organisations are becoming entrepreneurs. In our view, many of these people could now be persuaded to spend time with younger growing businesses and would have a lot to contribute.

5. *The role of the foresight programme in fostering networks and identifying priorities*

5.1 We do not yet have any clear evidence of how this initiative has directly and specifically impacted on the flow of business proposals to the UK venture capital industry. One benefit, however, of the initiative has been that it appears to have encouraged greater dialogue between scientists and industrialists.

6. *The role of the engineering and physical sciences research council in fostering technology transfer*

6.1 We view the council as an extremely important source of funding for ideas that can ultimately be turned into viable commercial technologies. We feel that it is a shame that a small portion of the council's funding could not be spent on its most promising ideas to help these be investigated for their commercial potential. The objective of this would be to make the transition between council-funded projects and commercially funded projects a less difficult one and the gap between the two types of funding less of an obstacle. We believe that a small shift in the council's priority, away from, say the bottom 5 per cent of its priorities in academic fundings, towards the investigation of commercialisation, would produce a very large effect in the number and quality of start up technology companies based on its funding.

7. Progress made towards implementing those recommendations of the science and technology committee in the previous parliament in their report on "The routes through which the science base is translated into innovative and competitive technology" relevant to the field of engineering and physical sciences.

7.1 No comment.

*20 March 1998*

## APPENDIX 14

### Memorandum submitted by the Business Link National Chief Executives' Forum

1. Introduction

1.1 Business Links exist to offer world-class support to local companies, particularly SMEs, to enable them to successfully compete in world markets. Business Links build on the best of the expertise available from Chambers of Commerce, TECs, Enterprise Agencies, local authorities and government departments in order to provide SMEs with a "one-stop advice shop".

1.2 The Business Link National Forum's principle objectives include:

- advising government and national partners on issues affecting the provision of quality services to SMEs;
- taking the lead in implementing DTI's policies for Business Links; and
- canvassing, and representing views from regional Business Links.

1.3 The following comments are pooled from a canvass of Innovation and Technology Counsellors (ITCs) operating in Business Links throughout England.

2. Recommendations

2.1 SMART needs increased funding, submissions need to be more regular throughout the year and timed to suit customers.

2.2 ITCs should be involved in both SMART submissions and the final project and execution.

2.3 The various LINK technology areas should be open for submissions for longer periods of time and LINK funding needs to be focused on the needs of business as well as that of the university.

2.4 The Foresight programme needs to be presented in a less academic way which will capture the imagination of SMEs.

2.5 TCS funding needs to be increased and projects should require a statement of support from their local ITC.

2.6 Funding should be available which provides SMEs with part/matched funding for "in-house" product/process development.

2.7. The bureaucracy involved in accessing schemes should be reduced and delays between a scheme ending and its re-birth months later should be avoided.

### 3. SMART

3.1 Business Links discuss SMART applications with companies, providing impartial advice on project registration.

3.2 SMART is used by a fair proportion of SMEs and is perceived by many to be a relatively good scheme, but there is some feeling that the previous SPUR programme was better.

3.3 SMART is felt to need increased funding to enable wider support for feasibility assessment (research) and development for new technologies/concepts leading to new products and processes.

3.4 Some ITCs have commented on how they are too easily excluded from SMART applications for confidentiality reasons when they have not been involved from the start with the submission of that application. It is felt to be vital for adding value that ITCs are involved in both the submission and the final project and its execution, because of their wider business experience than most GO staff.

3.5 Submissions need to be more regular throughout the year and timed to suit customer/market needs rather than the availability and timescales of GO staff. The timescales should be shortened.

3.6 Relatively few companies have been successful in their applications for SMART II.

3.7 In some areas there has been a perceived gap in what SMART could offer and a new product/process development grant has been introduced. This offers direct funding for projects with a much lower expenditure of a typical SMART project, and therefore complements the SMART scheme.

### 4. LINK

4.1 LINK is much less well used and has proved difficult to access. This has often been due to the timescales involved, as the various technology areas are only open for submissions for short periods of time. This is convenient for the scheme administrators rather than being focused on the needs of the client companies.

4.2 The feedback provided by companies and universities at presentations of the LINK scheme give a good impression, but the funding appears to be largely focused on the needs of the university.

### 5. Foresight Programme

5.1 Few SMEs know, and even less understand, how they can make use of this programme. There is a feeling that the programme is good but has not been promoted to SMEs particularly well and is too academic in its appearance.

5.2 The events which have been organised so far, have lacked focus and have not really struck a chord with SMEs. In addition, little feedback has been received from some local organisers of Foresight events.

### 6. Intellectual Property Rights (IPR) and Patenting

6.1 Collaborative R&D generally takes too long to access and companies are concerned with IPR.

6.2 The cost of other than UK patents often proves to be a limiting factor in applying for patents and registering designs, especially for lone inventors. Innovation credits were a useful aid to overcome this but no longer exist.

6.3 Assistance in IPR and patenting is often offered through "advice clinics", where one-to-one advice is provided by a patent agent and/or the local patent information service.

### 7. Technology Transfer

7.1 Basic skills training has often proved vital as companies have moved from traditional engineering into more innovative areas.

7.2 Various agencies and schemes are used by Business Links to foster technology transfer, eg Sheffield Technopole, FUSE, local Universities. These have involved innovation in product and process technologies, and schemes such as TCS have helped to plug the skills gap as new technologies are introduced.

7.3 TCS is viewed as a particularly good scheme, but again funding seems to be very limited. Some ITCs have suggested that its essential that they're involved in the monitoring of TCS projects and that they should require a statement of support from the local ITC as is the case with the CBP scheme. The involvement of

ITCs will help to maintain a business focus, but there appears to be no facility for inclusion of a budget for ITC time. This is crucial for ITC involvement and would also contribute to the income generation targets for ITCs set by the Business Links.

8. Financing Research and Innovation

8.1 The provision of finances "appears" well served via numerous different schemes but many are geared to major projects. Innovation within SMEs can involve relatively small funds, say up to £20K, which is still a major investment to a small company.

8.2 SMART is generally viewed as one of the best sources of finance, but is significantly underfunded, whilst other forms of assistance are focused on providing matched or part funding of "external" assistance eg from a consultant or university.

8.3 There needs to be funding available which provides SMEs with part/matched funding for "in-house" product/process development (ie where the main effort does not necessarily include substantial amounts of consultancy/university assistance) that can be accessed by ITCs. This would enable ITCs to be directly involved in particular projects and provide the necessary controls.

8.4 There is a real need for finance for R&D outside of Government laboratories and Research Agencies to help new ideas grow—many developments come from very small SMEs or inventors.

9. Other relevant Business Link Services

9.1 Innovation and Technology Counsellors and Design Counsellors provide advice/consultancy services to SMEs, drawing on their own skills or directing companies to assistance available from local and national authorities, universities, consultants etc.

9.2 Business Links assist SMEs in accessing various schemes, eg. SPUR, MiB (Microelectronics in Business), Craft, Recraft and local initiatives, in addition to the ones discussed above.

9.3 Business Links provide information on national centres of expertise and Benchmark best practice companies, eg by utilising The UK Benchmarking Index.

9.4 Business Links introduce companies to expertise and facilitate technology transfer from Universities (eg some Business Links have University Brokers who are responsible for this).

9.5 Some Business Links provide programmes to explore a business process (eg. Product Development). This examines the basic process, provides consultancy to apply best practice in this area, and offers networking/experience sharing opportunities. These programmes also provide access to further schemes, eg SMART.

10. Accessibility and Bureaucracy

10.1 Most schemes are heavily bureaucratic and so do not encourage access by ITCs or individual companies. It is acknowledged that submissions should be comprehensive, but improving the ease of access to most programmes would encourage more to apply.

10.2 Administering organisations should in principle be open for submissions throughout the budget year or programme duration. It is appreciated that this may have financing implications but is necessary if we are serious about innovation and want to be able to compete in global markets.

10.3 There is a general feeling that academia works at too slow a pace.

10.4 It is particularly frustrating when there is a delay between a scheme ending and its re-birth many months later.

11. Other Comments

11.1 The research topics publicised in the EPRSC "Newsline" are not applicable to the SMEs that many Business Links deal with as they're at the smaller end of the SME scale.

11.2 Environmental issues are being widely raised. More support could be given to encourage companies to move towards good environmental practice.

11.3 Some ITCs feel there is good support for companies wishing to assess/apply new electronics technologies or access EC schemes (eg FUSE).

*15 July 1998*

## APPENDIX 15

### Memorandum submitted by Cable and Wireless Communications

1. Introduction of Organisation

Cable and Wireless Communications (CWC), a British company, is a licensed telecommunications network operator. The parent company of CWC is Cable and Wireless plc, also a British company. Cable and Wireless Communications acquired Anite Networks in February 1998. Anite Networks was one of the two companies taking part in an innovation development programme jointly funded by the Department of Trade and Industry (DTI), and the Engineering and Physical Sciences Research Council (EPSRC). The other company in the consortium was NORTEL in Harlow, Essex. The university partner within the consortium was Queen Mary and Westfield College of the University of London. The project was entitled ARMAN standing for ATM (Asynchronous Transmission Mode) Resource Management, running from March 1995 to July 1998.

2. How and Why We Took Part in the LINK Programme

A lecturer from Queen Mary college contacted our technical director inviting our company to send a representative to the launching of the LINK programme. We attended the meeting and found the procedure for applying quite straightforward.

The LINK programme emphasis was on setting up small consortia (ie about four partners), and on defining project areas that had potential of generating revenue in benefit of UK plc. The LINK programme committee and the programme management set up by the DTI/EPSRC were helpful regarding the completion of grant application forms, and the highlighting of key issues relating to the programme objectives.

3. Our Involvement in LINK and the Achievement of Objectives

Our involvement in LINK has met our objectives despite the fact that our company changed hands during the duration of the project (three and a half years). We were able to carry out experiments to test out our innovative approach to modelling network services during the duration of the project.

4. The Impact of the LINK ARMAN Project within Cable and Wireless Communications

The success of the ARMAN project has resulted in the formation of a Data Modelling team within CWC. We have now started carrying out modelling tasks for the emerging information super-highway system being commissioned by CWC.

5. Barriers Regarding Gaining More From LINK

The level of financial support from the DTI was rather small when compared to the current cost of supporting a researcher within an industrial environment. The ratio of the cost of reporting on the project to the financial assistance obtained to pay for technical investigations was rather high.

6. Overall Assessment of the Scheme

The scheme was a very effective way of encouraging industry to get involved in focused advanced technology projects that did not involve carrying out loose investigations.

*16 February 1999*

## APPENDIX 16

### Memorandum submitted by Cast Iron Services Ltd, Burton-on-Trent

Cast Iron Services Ltd, are a small UK company, based in Burton-on-Trent. The Group has a turnover of £13 million and a workforce of 50 people. The company is involved in the manufacture and sales of drainage products. To help develop an efficient drainage system for bridge decks, thus prolonging bridge life, we embarked on a collaborative research project under the LINK scheme.

After we had established the need for a research project, we assessed several potential partners before deciding upon the University of Birmingham. On discovering the true costs of the research from the university staff, they suggested that the work might be innovative enough to be covered by the LINK scheme. This was the first we had heard of the LINK scheme. Our reasons for deciding to participate were twofold. Firstly, without the extra financial support, we as a small company would not have been able to fund the work. Secondly, since the main ultimate Client for the end product was the Highways Agency, we felt that the involvement of the Department of Transport in this project would be beneficial.

In collaboration with the university staff, we found the process of contacting LINK, completing application forms, etc, to be very straightforward. The LINK staff were very helpful at all stages. Thus, we found that our application was successful.

Our objectives from the research were to develop a new bridge drainage system, which would overcome the established problems of existing systems. These included poor hydraulic performance, liability to silting up, leakage problems and strength issues. The result of our involvement with LINK and the University of Birmingham is that we met all of the above objectives. The product developed is the most hydraulically efficient on the market, is self cleansing and has virtually leak proof joints.

The impact that LINK has had on our company is difficult to assess. It has no doubt enabled us to bring to the market a well engineered and tested product. It has also for the first time in this country meant that for this type of bridge drainage, that engineers can design on the basis of the real capability of a system, rather than those put forward by the manufacturer. It has also opened our eyes to the value of Research and what can be achieved by collaborative ventures.

The problem is the market place, not the LINK scheme. We have spent a great deal of money, as well as valuable staff time on this development, only to find that most engineers do not want to know. They are prepared to continue to accept the claims of manufacturers of untested systems and hence units which may not meet the hydraulic requirements are being used on site. Most of the time engineers specify a box with dimensions x, y and z and assume that all boxes of the same size will give the same performance. The research project showed this to be a fallacy. On a recent project, our new system was rejected on the basis of unit colour, while another untested system was accepted because of its colour. Arguments about hydraulic performance, leakage and possible silting up were ignored. On many other jobs, we have lost out narrowly on price to systems which if they had been rigorously tested would have been shown to not have the capacity for the job.

Our overall assessment of the LINK scheme is very favourable. If we ever found the need to carry out research in the future, we would look towards LINK for assistance. From start to finish the staff have been very helpful and have always made themselves available to provide advice and assistance. Our area of concern is more to do with the dissemination of the findings and how research findings are dealt with generally. The results of projects like this one should be taken up by relevant organisations, like the Highways Agency, so that they can be incorporated into national standards, etc.

Thus, we are very happy with the findings and outcome of our collaborative research with the University of Birmingham, under the auspices of LINK. We are very unhappy with what has happened since. It is good to market and sell a product that you know performs its function efficiently and for which you have hard data. However, it is all pointless if designers and clients do not implement research findings. If we had known that this would be the outcome, we would not have spent our money in this way. It would have been better commercially, to optimize the design of a box of similar proportions to our competitors and then sell it at a market price. We would undoubtedly have made more profit. The only people to lose are the bridge owners who continue to get hydraulically inefficient units with leakage and silting problems.

*19 January 1999*

## APPENDIX 17

### Memorandum submitted by the Centre for Exploitation of Science and Technology (CEST)

1. Introduction

CEST is a charitable trust with the mission to identify new business opportunities for science and technology and to facilitate their realisation by bringing together decision makers from industry, academia and government to agree collaborative action. CEST is one third funded by Membership (its Members include: DTI, DoH, DETR, Environment Agency, WDA, IBM, Glaxo, BG, BNFL, Rolls-Royce, Pilkington as well as Leeds and De Montfort universities) and two thirds by collaborative programmes (with themes including: Managing the business risk of GMOs; New opportunities for science and technology based business in an ageing society; New aspects of supply chain efficiency built on distributed data; Promoting the markets for new sensor technology; and benchmarking needs and opportunities for knowledge management across industry). With a staff of 18 and a budget of approximately £1 million CEST acts as an "honest broker" at the interface between business and technology. It does not have vested interests (eg IPR or shareholders) and is a champion of "collaborative advantage" where organisations work together to realise business opportunities in the white space between traditional industries and business processes. From this perspective CEST actively seeks to stimulate new thinking and policies to promote the commercial uptake of research. Visit us on www.cest.org.uk.

2. Summary

In its submission, CEST will touch on the following:

— that in the portfolio of national research, from blue sky to near market, new groupings of stakeholders are needed to grasp and promote pre–competitive research—and bring it to market;

- that communication of information which might affect investment decisions, between technology and market/financial communities, regarding innovation in the physical sciences is not very effective;
- that Foresight needs to be expressed to target industry segments and their representative associations, particularly SMEs, in terms of everyday business benefits to which they can relate;
- that many of the key themes highlighted by Foresight require a true multi-disciplinary approach, where, for example, the physical and engineering sciences operate alongside social sciences and medical research;
- that as time pressures and speed of change increase and resources become scarcer the generation and dissemination of new knowledge needs to be explicitly recognised, valued, and optimised by beneficiaries; and
- new processes of knowledge management will be needed to find and link research areas to improve the overall effectiveness and responsiveness of the research base.

### 3. Clusters at the Business/Technology Interface Should Promote Sectoral Innovation

In CEST's view the part of the innovation gap which requires special attention now is that which potentially provides innovation to entire sectors of industry. Appendix 1 describes our view of the innovation landscape which leads to this opinion, emphasising the overwhelming importance of interaction in the generation of new ideas.

4. Mechanisms are in place to enable individual companies to access new ideas—however, the "winner takes all" effect of this means that overall impact on industries can often be detrimental.

5. In CEST's view clusters of companies—brought together by shared interest in issues or technologies and prepared to share the risks and opportunities associated with them—provide the best opportunity to stimulate sectoral innovation.

6. Even temporary clusters can support the interactions that lead to an important class of innovation (noting that innovation is the successful exploitation of a new idea). CEST strongly believes (and can draw on numerous examples) that by working together, companies which may well be considered to be competitors in the marketplace are potentially able to achieve benefits which would not be available to a single company in a "winner takes all" environment.

7. The research councils (and hence the Government) have typically focused their efforts on promoting generic research—directing almost all their resources at academia and assuming that an unseen but nonetheless present technology transfer process will result in cost effective transfer of benefit to industry.

8. CEST suggests that if the EPSRC (in concert with, for example, the DTI) were to stimulate and engage clusters of players closer to commercialisation it might be possible to promote the capture and exploitation of new ideas on a cross sectoral risk-sharing basis. It would be for the clusters themselves to decide where pre–competitive collaboration ended and competition began—and also to manage the IPR issues which emerge. From this emerges the idea of sectors becoming self-regulating—to avoid inefficient duplication of effort.

9. However, CEST also recognises that significant barriers need to be overcome to make this "collaborative advantage" real. The successful identification and assembly of clusters that are meaningful and useful is both difficult and infrequent. This is the market that intermediary bodies operate in—their skill in catalysing innovation creating clusters should be recognised and fostered.

10. These recommendations align with others made below.

### 11. Communication of Business Risk

With the exception of the pharmaceutical industry, CEST observes a general lack of value–adding communication between the financial and technology communities. Both sides vehemently deny their responsibility for this. In particular the financial community tends to argue that it does understand technology—but often chooses not to invest in it.

12. CEST suggests that other sectors of R&D terrain might learn important lessons from the level of understanding that the pharmaceutical industry and the financial community manage to share. This should cover the structured communication and sharing of information—for example "controlled release" of information regarding progress towards, and achievement of, research milestones the implications of which are understood by both parties.

13. We suggest that, whatever the financial arguments about non–technology investments being more understandable and therefore more attractive, it must be beneficial to the physical sciences and engineering community to communicate, in a more effective manner, with investment analysts and business in general, about the nature of the benefits and risks of novel applications.

14. CEST would like to see EPSRC liaise with appropriate professional bodies, financial institutions and trade associations to identify areas of research which would benefit most from such an enhanced communications approach. We believe that both software and electronics may be suitable candidates. The objective should be to increase the appetite for investment in technology ventures to a level experienced in the USA.

15. A simple embodiment of such a system might be the use of agreed terminology in company reports and press releases to describe the status of a specific project or to describe the mix in a company's R&D portfolio. In CEST's view such standardisation should be seen as a sectoral or national issue that can deliver benefit to both financial and technology communities.

16. Forward with Foresight

The Foresight programme, which is now being promoted actively to industry, has delivered significant and well publicised benefits to large corporates—in particular regarding alignment of their research efforts with national and cross sectoral priorities. However, the challenge has been to deliver the programme and the process to SMEs, and there is little evidence to date that real progress has been achieved here. Typically these smaller companies have very short time frames for thinking strategically, if they do it at all. They also tend to look hard for immediate and tangible business benefits, before they involve themselves in planning for any future, that involves exploitation of Innovation and Transfer of Technology within the Engineering sector.

17. CEST suggests that it is vital to work with intermediary organisations such as Trade Associations and industrial bodies like the IOD (which represents many SME proprietors), and that the message about Foresight, which will be promoted now, during and after the next round of Foresight, must be founded firmly on tangible and near-term business benefits such as identification of future markets and products which such companies can grasp profitably.

18. This may require a different process for defining and developing the Foresight deliverables during the Foresight programme planned to start in 1999. Having worked extensively with smaller players CEST is aware of some of the factors which catch their attention (such as insight into significant industry players views of the future) and how to weave these into the Foresight process.

19. A Multi-Disciplinary Approach to Research Funding

In addition to focusing Foresight, as an industry oriented programme of research using the above approach, CEST is of the view that the EPSRC could use such an inclusive multi–disciplinary methodology for guiding many of its own thematic research programmes.

20. CEST is of the opinion that several of the "big picture" issues highlighted by the Foresight process are most likely to be successfully tackled by a combination of disciplines across the social, physical and life sciences. The relative novelty of these issues results in the specific roles for individual disciplines and the nature of their successful interplay being as yet unclear.

21. Furthermore, CEST suggests that factors such as the social, environmental and political impact of scientific and technology innovation are inadequately considered when priorities for such innovation are being set. While remaining fundamentally supportive of curiosity-driven research, we feel that an improved understanding of how new areas of research might impact on society should develop in parallel with the enabling science.

22. Although some themes like EQUAL (promoting a fuller role in society for the elderly and disabled) are being promoted by central government, across all research councils, at present we observe little more than lip service being applied to the multi-disciplinary approach. In EPSRC's call last year for EQUAL projects in the Built Environment there was the specific requirement for a sponsor or proponent from the social/third age communities for physical sciences projects—however, the call was not able to accommodate projects where players from the social and physical sciences worked together to home in on appropriate solutions.

23. We would like to see a subset of EPSRC resources being focused on a better understanding of the likely uptake of its mainstream research projects and on the development of new themes in combination with other disciplines.

24. The Role of Knowledge

25. *Valuing New Knowledge*

In recent years much effort has been expended in making organisations highly focused and cost-effective ("lean and mean"!). Processes that have not in the past been measured and valued (such as the generation of innovative ideas) have been rendered increasingly difficult as "thinking time" has been shaved.

26. The erosion of the ability to react innovatively to the emergence of opportunities and threats has the potential to adversely affect the UK's economic position. The process of innovation and the inspirations for innovation need to be explicitly recognised by UK companies, and sufficient space and time dedicated to

them. An organisation should perhaps not pride itself on spending 10 per cent of its turnover on R&D, but rather aim for 15 per cent on processes which in general lead to innovation (including R&D, but also networking, forming partnerships and other joint ventures, participating in collaborative clubs and other clusters).

27. Government should act to encourage the explicit identification and measurement of and attribution of value to innovation processes. Possible steps could include:

- publication of an innovation scoreboard which would be more useful than the current R&D scoreboard;
- provision of grants to attend conferences (this would be a good way of indicating the perceived value of such activities);
- promotion of virtual networking opportunities; and
- tax breaks for spending on innovation fostering activities in general (this would send a powerful signal to the commercial world).

28. *Managing the Nation's Knowledge*

The research community is notorious for reinventing wheels. Poor communications have made it very difficult to ensure that initiatives are not unintentionally duplicated—either within a research sector or across sectoral boundaries.

29. Publications, databases, websites and information exchange exercises all help to act against this—however the complexity of rapidly developing subject matter and our difficulty in categorising it in universal terms makes the challenge significant.

30. CEST suggests that an (idealised) system where knowledge is input and drawn upon freely as it emerges would be in the interest of society as a whole. This, of course, argues in favour of a planned economy—rather than a free market where winner (with exclusive patent rights) takes all. One might argue that government through the organ of research councils is seeking to act more to the benefit of society and might think this way. There are, of course, risks that free market players might observe and benefit from such a position. We note with interest the "knowledge pool" concept being floated for Foresight 2000 and believe that similar underlying values could benefit the research community as a whole.

31. We suggest that the EPSRC might consider that an obligatory knowledge exchange for participants in its sponsored projects would improve its contribution to knowledge sharing at a national level. Such knowledge exchange plans should quickly be mirrored by other RCs in a manner which enables cross-referencing.

32. Conclusion

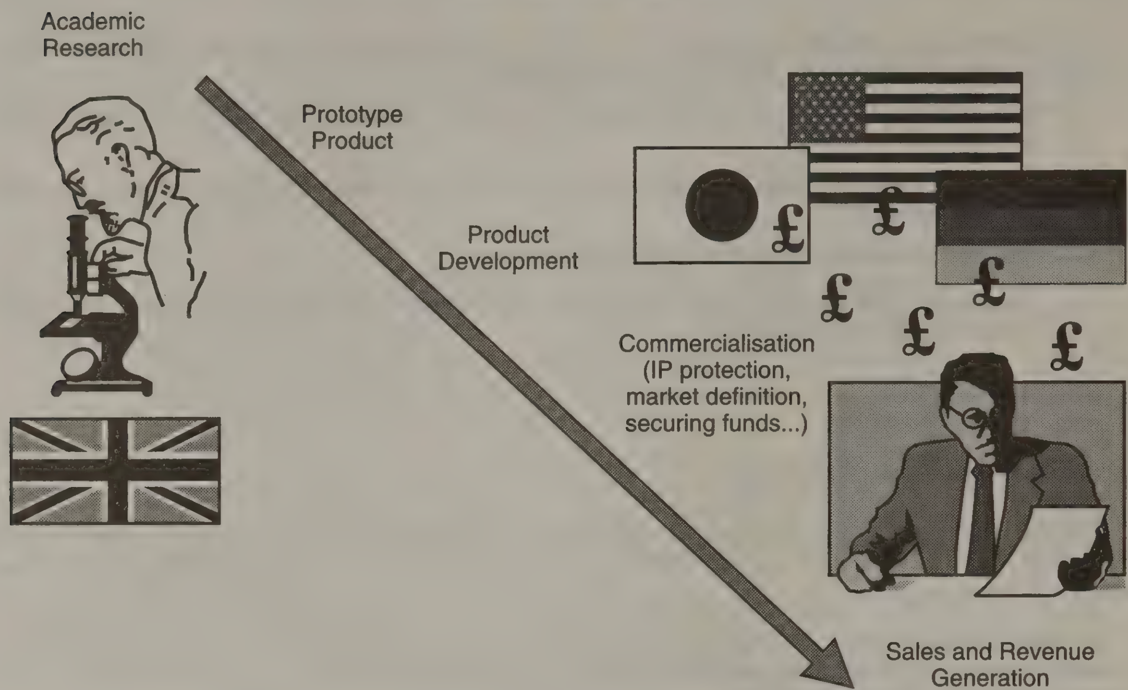
CEST believes that innovation has many origins—only one of which is new science—and that interaction between players of different outlook and discipline is an important element in the process. An area where this interaction is lacking is in research to benefit whole sectors of industry or markets—we believe that clusters of organisations are the most potent hosts for such innovation, but recognise that the management of this interaction presents challenges in itself. CEST would like to see the EPSRC becoming more involved with such clusters—including the financial community, trade associations and interest groups and participating in structured two-way communication to enhance the understanding of each others point of view, leading to improved flow and exploitation of ideas to the benefit of the UK as a whole.

33. The Origins of Innovation

There is always a danger that debate about physics and engineering innovation in the UK is frustrated by outmoded views on its provenance and how it is best commercialised. This typically puts (British) academics at one end of the innovation channel and (foreign) companies at the other end generating profits. This view is summarised in the diagram below.

**Diagram 1**

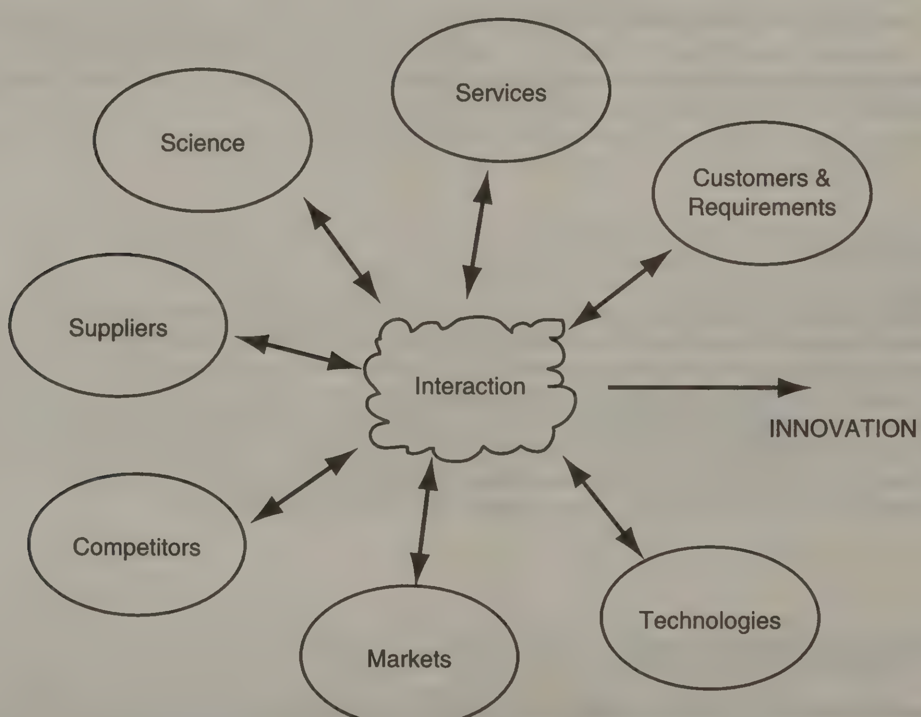
**UK Innovation in Physics and Engineering: The Historical View**




34. Of course, innovation and its subsequent exploitation do not work like this. Innovation is the successful application of new ideas, ideas which need not be academic in origin, and successful application which does not have to follow any pre-planned "hand-me-down" route.

35. In particular, CEST observes innovation frequently coming from interaction between players—for example between industry sectors, between different parts of a supply chain, between academics and scientists, and so on. This is illustrated below:

**Diagram 2**




36. New ideas from engineering and physical sciences are important components of the web of interactions that underpin commercial innovation—but they are not "the whole story".

37. Innovation—defined as the generation of new ideas and their successful exploitation—depends on the quality and quantity of interactions—between nodes and within nodes on the network above.

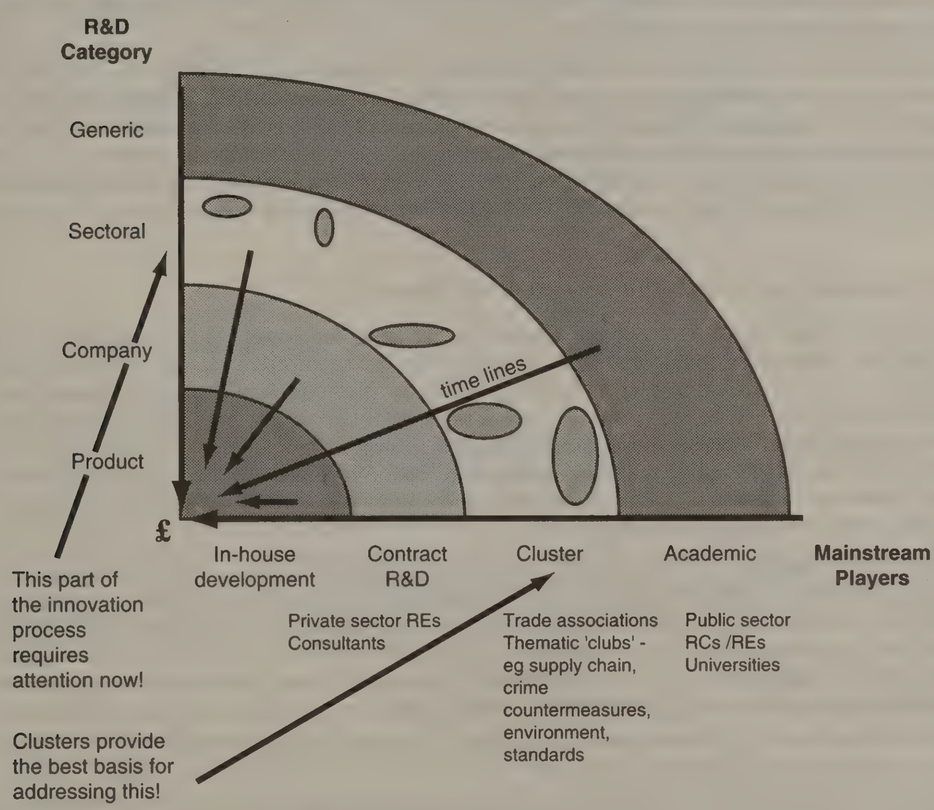
38. Developing this theme further, CEST believes that there are a variety of attributes of environments which are particularly supportive of innovation. In general (although this is an area notoriously difficult to generalise), one can plot a graph of different types of innovation (as an idea moves towards successful exploitation in a specific company) against the type of organisation which is handling that innovation.

39. CEST has for many years suggested that in many cases an innovation gap exists—where innovation is stifled by lack of management interest or short termism before the benefits shine through. The diagram below tries to show in some more detail who is doing what and where the innovation gap is most relevant.

40. In CEST's view an important (and currently poorly covered in the UK—represented in the graph by the patchy shading in this sector) part of the "innovation landscape"—is that leading to sectoral innovations. By definition these involve a group of companies taking up an innovation to gain a shared benefit. In an age where such players are lean and mean the resources needed to seek and grasp opportunities which are beyond the horizons of individual companies are badly stretched. We believe that the most potent grouping to achieve progress in this situation is the use of clusters of organisations with a shared purpose. Such clusters might be already in place in trade associations or assembled to address a specific need—such as lobbying groups or groups to address specific issues. They may be temporary or permanent.

**Diagram 3**

**CEST's View of the Innovation Landscape**




*10 March 1998*

## APPENDIX 18

### Memorandum submitted by the Chemical Industries Association

INTRODUCTION

The Chemical Industries Association is the major body representing the UK chemicals sector, which is strongly dependent upon scientific and technological innovation for its competitiveness. This enquiry is, therefore, of great significance to our industry.

The enquiry seeks information on how companies decide on developing new products and processes, and what factors influence those decisions. In general, such decisions are taken based on market, customer and competitor research. Companies also consider what benefits might be derived from existing or novel research and technology, in terms of product or process improvement, or to develop entirely new products and processes. Decisions are thus based upon three main factors: understanding of market / customer needs;

knowledge of science and technology opportunities; and understanding of how to apply that knowledge to meet those needs.

Before addressing the specific questions posed by the Committee, we would like to outline what we perceive as the respective roles of industry and government in the process of innovation.

*Innovation: the Role of Industry. . .*

Successful innovation depends upon the whole range of business skills: high quality management; an understanding of customer needs; sophisticated market research; effective sales and marketing techniques etc. Many of the factors which influence an industry's innovative performance are, therefore, internal, and individual companies are in a position to do much to help themselves.

*...the Role of Government*

Government support, whether at national or European level, is essential to foster innovation in industry. That support should be focused upon achieving two equally important goals. Firstly, government must ensure that there is a strong public sector research and education base, at all levels, which provides industry with access to leading-edge research expertise, and the highly trained manpower which is the life-blood of technology-based industry. Secondly, government must make every effort to ensure that the climate in which companies operate (legal, regulatory, fiscal and social) supports those which innovate, and encourages others to improve their innovative performance.

Achieving common purpose between government and industry is the key to carrying out these roles effectively, and the specific headings under which the Committee seeks evidence are highly relevant in this regard. Before addressing these, however, we should stress that chemical companies need to be globally competitive to survive and they will naturally use the best research facilities available to them, wherever they may be. They will only invest in, and hence develop, the UK science base if its output (people and expertise) is of world class quality, and is accessible in a customer-friendly way.

(i) *The industrial application of government funded research*

The 1993 White Paper, *Realising our Potential,* and studies such as "The Routes" enquiry (referred to in section (viii), represented a welcome effort from government to improve industrial application of government funded research. We would not wish for this to be taken as a call to shift the emphasis of academic research towards the applied end of the research spectrum. Government funded research must be directed primarily towards basic, fundamental research. Industrial application from such research is usually a long term process. Government can help to improve the eventual application of fundamental research by ensuring that funds are deployed strategically in broad areas of science and technology which are most industrially significant. Here, the role of Foresight is all-important.

Research in academe includes (rightly) strategic and applied activity, usually associated with industrial support. Funding is often split between government and the industrial sponsor or, in the case of purely applied contract research, wholly funded by industry. In an enquiry recently conducted by the EPSRC, it was noted that the chemical and pharmaceutical industries did not participate to the degree expected in collaborative research projects with universities. This study exposed some barriers to industrial involvement in collaborative research which are highly relevant here.

- Approval for grants takes too long at peer review stage, especially if other government departments (DTI/OST) are involved.
- Postdoctoral researchers can only be accessed with 100 per cent funding by industry. The cost of sponsoring a postdoctoral student is roughly equivalent to recruiting two new PhDs into the company.
- Postdoctoral research support is cheaper and more flexible (in terms of engaging the person for fixed-term projects) elsewhere (the US, for example).
- The management and ownership of intellectual property rights remain problematic in collaborative, jointly sponsored research projects.

The CIA recognises the efforts made by the EPSRC to engage industry in research council programmes, and to include industry in establishing its research support strategy. We regard this latest consultation by EPSRC to be another useful initiative aimed at maximising the industrial application of public sector research, and we look forward to a continued, fruitful dialogue with the Council to address the various points made here.

Finally, we would like to stress a point made in the introduction, that high quality research and technical recruits are the life-blood of the chemicals industry, and it is arguably this resource which we prize most highly. The benefit to industry from government funded research is not just the research itself, but the people associated with it.

(ii) *The respective roles of government laboratories and independent research and technology organisations*

Government laboratories and independent research organisations can be of some value to companies, by disseminating knowledge and fostering networks in particular areas of research. Because they usually address what might be termed "generic" research areas, as opposed to company-specific projects, they rarely add value directly, but they can be integral to the success of projects by complementing research performed within companies, or in collaboration with a university partner. Independent research organisations can also provide a degree of commercial awareness which is often lacking in universities.

(iii) *The operation of government schemes designed to promote collaboration in, and industrial application of, research*

Our comments in section (i) are relevant and, again, we would like to refer to our response to the EPSRC's enquiry as to why chemical and pharmaceutical companies do not participate as strongly as expected in government funded collaborative research.

Companies differ in their relationships with universities, depending upon their size and their business: there is, for example, a marked difference in science base interaction between a small chemical company and a large, multinational pharmaceutical company. However, CASE awards are universally liked and well used within the chemicals sector, because it is a simple and cost-effective way to build relationships with universities and to gain insight into new areas of potentially useful research. We would like to take this opportunity to call for an increase in the number of industrial CASE awards, especially for small and medium sized companies.

Although the LINK scheme is also well used, and has provided many of our member companies with real added value, it can be difficult to set up projects under the scheme, especially with regard to intellectual property ownership. This factor is perhaps the most significant stumbling block encountered by companies wishing to take advantage of the academic science base. We welcome the efforts made by the CBI to address this through the recent publication of *Research Partnerships Between Industry and Universities—a Guide to Better Practice.*

(iv) *Intellectual property rights and patenting*

We refer to our comments under (i) and (iii).

The problems surrounding intellectual property rights from collaborative research are based, in many cases, upon a mutual lack of understanding, between industrial and academic partners, of each other's expectations regarding the outcome of the research project. If intellectual property is at all an issue, then the prime expected outcome for the industrial partner will be commercial success. Patent rights are commercial instruments and, in general, they are best managed and exploited by the industrial partner, to the benefit of both partners. Naturally, rewards should be commensurate with inputs. The crucial factor is to ensure that all matters regarding project expectations, time—scales, funding and intellectual property rights are fully agreed and understood by both parties before the research commences.

There have been suggestions, at the level of EU patent law, that there should be grace periods for research performed in universities which would allow publication of results without compromising patent rights, at least for a defined period of time. Although the drive to publish in academe has caused patent-related problems for industry in exploiting academic research, we do not support the idea of grace periods, since there is little doubt that they would tend to increase litigation and third party interference action for the patent system in general. What we believe is needed, as we have stated above, is greater understanding of intellectual property rights and their management and use in the context of collaborative research.

(v) *The provision of finance to support enterprises involved in the application of research and innovation*

Many larger companies have enterprise units to provide venture capital and business support for start-up companies which can make use of science and technology owned by the company, but which has become redundant to its business focus. This can be a very effective way to improve the exploitation of research and derive added value.

The issue of tax incentives for research and development, which exist in many countries, has been widely debated within the chemicals industry for some time. There are differing views as to the value of such provisions and we are unable to provide a definitive, industry-wide view on the matter. What is clear, however, is that the mechanisms by which any such fiscal incentives might be established must be very carefully examined, in full consultation with industry, so that they truly work to increase research activity and its commercial exploitation.

(vi) *The role of the Foresight Programme in fostering networks and identifying priorities*

This Association played a major role in the Foresight Programme when it was first established, primarily in identifying research and technology priorities. Since then, in partnership with government and the learned societies, we have been actively involved in disseminating the results of Foresight and fostering networks around priority areas. Our Specialised Organic Chemicals Sector Association (SOCSA) has also been heavily involved in such efforts on behalf of its members, many of which are SMEs.

Foresight has had a significant and welcome impact on the strategic deployment of government funding for research. There remains a great deal of work to be done in exploiting the business benefits of Foresight, and widening the pool of people actively engaged in the process. To this end, we welcome the imminent new round of Foresight consultations and, if anything, we intend to be even more actively involved this time around.

The Foresight Programme is key to achieving successful exploitation of the science and engineering base, which we in turn believe is key to the long term success of our industry. We hope that government will continue to help champion the Foresight process and, more specifically, we hope that the Chemicals Panel will continue to provide the focus for the industry's efforts under the initiative.

(vii) *The role of the Engineering and Physical Sciences Research Council in fostering technology transfer*

The EPSRC has responded extremely well to the recommendations laid out in the 1993 White Paper. The Council has been very proactive in seeking industry's advice on research funding priorities, and the mechanisms by which their funds are disbursed (the establishment of the industrial CASE scheme is a good example, as is the consultation on collaborative research, referred to above). We believe that the EPSRC provides a good model for other research councils, with regard not only to practice, but also structure. A commonality of approach between research councils would greatly improve their effectiveness; although this enquiry concerns engineering and physical sciences, our member companies are dependent upon the entire spectrum of engineering, physical and biological science disciplines.

(viii) *Progress made towards implementing those recommendations of the Science and Technology Committee in the previous parliament in their report on The Routes Through Which the Science Base is Translated into Innovative and Competitive Technology*[8] relevant to the fields of engineering and physical sciences

There is no doubt that there has been progress to improve the partnership between the science base and industry, not least because of the Foresight Programme. However, to some extent, partnership between universities and industry has developed as a result of lack of government funding for university research and infrastructure, forcing universities to seek industrial support. While the net result, at face value at least, might be welcome, the driving force is certainly not. A successful partnership (of any kind) must be genuinely symbiotic.

The overarching recommendation of the "Routes Report" is that "if government policy is to encourage innovation then the process by which innovation takes place must be fully explored and widely understood. Policies introduced without understanding will at best be inefficient and at worst counter productive."

We believe that there needs to be better understanding within government (national and European) of how policies and legislation, in areas not directly concerned with innovation, affect industry's ability to innovate. Two very serious examples of this are:

— the Notification of New Substances; and

— the Biocidal Products Directive.

These regulations are necessary to ensure safety and responsible practice, and we fully support their aims and objectives. However, they have been implemented in such a way as to render them extremely burdensome to industry, and major barriers to innovation. In these cases, the processes by which innovation takes place were not explored and understood, and the chemical industry is suffering as a result.

Even where legislation is directly concerned with innovation, as is the case for the current proposal for a Directive on the Legal Protection of Biotechnological Inventions, the links between the seemingly esoteric issue of intellectual property law, and innovation, employment, industrial competitiveness, wealth creation and the quality of life, do not seem to be fully understood. This Directive is crucial to developing and exploiting innovation in the life sciences, but it is threatened, again, because the processes by which innovation occurs have not been widely researched or understood.

It is thus towards this aspect of the report's recommendations that we seek progress most urgently.

*16 March 1998*

[8] First Report, Session 1993–94 (HC 74).

## APPENDIX 19

### Memorandum submitted by the Committee of Vice-Chancellors and Principals

1. The Committee of Vice-Chancellors and Principals is the representative body for UK universities, and regularly submits evidence to public bodies on issues that affect universities and higher education.

2. CVCP was invited by the Science and Technology Committee to submit a memorandum to its current Inquiry. Specifically, CVCP was asked whether it knew of initiatives in UK universities similar to the practice in American universities of "paying academics at 80 per cent of the full rate for an 80 per cent university workload, thus allowing those concerned to pursue more commercial interests and, hopefully, make up the rest of their income".

3. The simple answer to the Committee's question is that contractual arrangements of this sort are not routine or widespread in UK universities. Special arrangements are occasionally negotiated, usually on an individual basis and typically at professorial or other senior level, but precise data on their extent is not available. The fields in which contracts of this sort are most familiar are in medicine and related clinical disciplines, where appointments allow for the combination of teaching, research and clinical duties, but there is no single dominant model.

4. The American practice is itself not ubiquitous and can vary—not all universities follow the practice of MIT, for example. A common version is full–time contracts lasting for nine months of the calendar year, with the expectation that research grants, or perhaps teaching in a third semester, will cover the rest—these latter options being perhaps more common than earning 20 per cent from industry. The 80 per cent/20 per cent formula has the appeal of simplicity ("one day a week"), but further information is needed to determine what it might mean in terms of academic workload and in level of remuneration (both of which vary from the USA to the UK).

5. A group of Vice-Chancellors and senior technology transfer managers from 11 UK universities visited last November seven universities in the USA with a track record in technology transfer, as part of ongoing work with the Gatsby Charitable Foundation. The aim was to consider what lessons could be learned from the US experience. The attention of Vice-Chancellors, like that of members of the Committee, was drawn to the nature of academic contracts in the USA. A report of the visit will be launched at a national conference on 11 February, a copy of which will be forwarded to the Committee.

6. The American practice on contracts may be less significant in itself than in what it is an indication of, namely that in certain commercially successful universities in the USA the emphasis is not so much on allowing staff to work for industry as positively expecting them to do so. This emphasis is expressed partly through contractual arrangements but more generally through the immersion of staff and students within a tradition of strong university-industry links. This includes extensive academic-industry collaboration, industrial affiliate programmes and community business orientation programmes. As a result, the most successful American universities have not only established a leading economic role but are also in the van in grappling with issues arising (equity share in start-up companies, IP rights, conflicts of interest, etc). It should be stressed, however, that this does not apply to all American universities.

7. 80 per cent/20 per cent contracts may thus be regarded in principle as an interesting approach, certainly worthy of consideration by at least some UK universities. But it is not clear that the practice could or should simply be replicated in the UK. Structural and cultural differences between the US and UK university systems should not be underestimated. It would be unwise to assume that a particular feature found in one system could simply be abstracted and applied in another and very different one. It is also worth noting that in the USA leading researchers rarely see undergraduate students, whereas in the UK senior academics teach at all levels.

8. It is unlikely that the practice would commend itself equally across the very diverse university sector in the UK, not least because ours (unlike the US) is overwhelmingly a publicly funded system. In addition, opportunities to recoup income foregone would not be equally available to all institutions and all staff. Encouragement to explore flexible arrangements would be more attractive, and more in keeping with a system of diverse and autonomous institutions, than any hard and fast approach.

9. It is worth pointing out that it would be a mistake to believe that contracts on the model cited would lower university costs—not simply because university salaries in the USA are often substantially higher than those in UK universities. Something that all universities would vigorously resist would be any suggestion that arrangements of this sort could lead to a lowering of public funding.

10. In the UK staff typically undertake outside work within the terms of their full-time employment. The UK system is not structurally designed to motivate staff to seek outside engagement and remuneration, but this does not mean that work outside the institution is not regularly undertaken. On the contrary, consultancies and other outside engagements are actively encouraged. They are seen, where consistent with university duties and mission, as activities beneficial to staff themselves, to their universities and to the economy. Consultancies are important ways of attracting and retaining staff in fields where university salaries struggle to compete with market rates. In some cases consultancy is a valued source of marginal income for the institution.

11. Overall the scale of outside earnings in the UK is not thought to be very great (probably less than the 20 per cent of the American formula), although the earnings may be significant in some individual cases. Some universities restrict consultancy earnings (eg a limit of 10 per cent of university earnings is common in medical schools). Exact figures are unavailable, because owing to Inland Revenue regulations the data can only be gathered on a voluntary basis.

12. The Committee will be aware that pay scales and conditions of service in HE are negotiated nationally in the UK. An Independent Review Committee (chaired by Sir Michael Bett) has been established to make recommendations on a new framework. In the course of 1998 the Review Committee invited written submissions, heard oral evidence and commissioned external research. The report of the Review Committee is expected early in 1999, and will form the basis for negotiations between employers (universities are represented by the University and College Employers Association) and unions.

13. In sum, contracts on the American model represent an interesting option, but may not be the principal issue in facilitating the commercialisation of research. In our view other factors are more important, not least the availability of finance to support new enterprises in the early stages of exploitation.

14. These and other issues will be covered in more detail in the report currently in preparation. CVCP would be happy to arrange for a representative to appear before the Committee to discuss what Vice-Chancellors learned on their visit to the USA.

*11 January 1998*

## APPENDIX 20

### Memorandum submitted by the Confederation of British Industry

INTRODUCTION

1. This paper represents comments from the CBI for consideration by the House of Commons Science and Technology Committee during their inquiry into "Engineering and Physical Science Based Innovation". It represents the summation of views gathered from members for previous inquiries and consultations, rather than a distinct consultation of our members.

2. This response is submitted after the original closing date for evidence, as agreed with the Clerk of the Committee. The reason for this, was to await the publication of the 1998 Innovation Trends Survey, on 15 July 1998. Attached to this response is the Technology & Innovation Brief[9], which summarises the results. The attention of the Committee is also drawn to the sectoral breakdowns from the full data analysis, which is available at www.cbi.org.uk/innovation. Further analysis of the data is possible and the CBI would be happy to explore this with the Committee.

OVERARCHING COMMENTS

3. The primary question that the Committee has posed regards "the manner in which companies in the fields of engineering and physical sciences decide on developing new products and processes and the factors influencing their decisions". This year's Innovation Trends Survey focuses on the attitude of companies towards innovation and it is this analysis which gives cause for concern.

4. The principle results of the survey indicate a drop in the level of expenditure on innovation from a peak in 1994. This trend closely mirrors other economic indicators such as business confidence[10] and growth in GDP.

5. It is wrong to suggest that the UK does not have companies or sectors that are world class when it comes to innovation, but the message from this year's survey is that many view innovation as an area to be cut during periods of difficult trading. Since the early 1990s the CBI and Department of Trade & Industry (DTI) have been promoting the message that innovation is the difference between a flourishing business and a sinking business. The evidence from this year's Innovation Trends Survey is that this message is only getting through in limited terms.

6. The focus of the Science & Technology Committee's inquiry is on the engineering and physical sciences. Much has been said about the poor exploitation record of the UK, especially in terms of the physical sciences. However, care must be taken in interpreting this viewpoint, as the link between the physical sciences research base and the market place is less direct than others (for example pharmaceuticals and chemicals). Many discoveries in this area are not directly exploited, but find their way into products and processes through intermediaries. Perhaps the best example of this is the application of laser technology, which originally was a technology looking for a market, but can now be found in telecommunications, cutting, medical health and many other sectors.

[9] *Not printed.*
[10] *CBI Industrial Trends Survey* (Published quarterly).

### The Key Drivers to Innovation

7. This year's Innovation Trends Survey asked respondents to rank the key drivers to innovation. By far the most important drivers were "customer expectations or requirements" (with a mean ranking of 1.9, with 1 indicating the most significant) and "competition" (mean ranking of 2.6). The least significant driver was "Government grants or tax concessions" (5.7).

8. Such a ranking is perhaps unsurprising as companies develop products and improve processes to meet customer requirements—companies do not look for grants to support research without knowing the market in which they are working. However, the ranking could also mean that companies do not view existing "Government grants or tax concessions" as incentives. Such a view may change if further incentives were available. Either way companies do not believe these will increase in importance in the future, but rather decrease.

### Inter–Change Between the Science Base and Industry

9. Despite these results we do believe that the Government should continue to support schemes that encourage the targeted exploitation of science and technology. People, through their skills and the ability to work together, are the primary drivers for technology transfer in every sector.

10. The types of scheme that have proved successful in recent years supports this view. The Teaching Company Scheme for example, has a good reputation both in universities and industry that receives an "associate". The fact that 50 per cent of associates are subsequently employed by the company in which they are placed and in total around three-quarters take jobs in industry, support this reputation. The quinquennial review of the scheme in 1996, although recommending some improvements, also recommended its expansion.

11. Similarly schemes such as the Postgraduate Training Partnership, the Industrial Quota Case Awards and the Engineering Doctorate all provide mechanisms to place individuals within a commercial environment, whilst maintaining academic rigour. Although many of these schemes are relatively new compared to the TCS, early indications are that the PTP is also increasing the numbers of graduates moving into industry [11]. If over time, this has an effect of increasing mobility between industry and universities this should facilitate the exploitation of novel technology and processes—an area that, in this year's Innovation Trends Survey, UK domestic companies seem reluctant to invest in.

### Foresight and the Role of the EPSRC

12. Since the 1993 White Paper on science and technology, there have been significant changes in the EPSRC. Many CBI members have felt these have been positive with the Research Council leading such initiatives as the Faraday network and the Industrial Quota Case Awards. We are encouraging the EPSRC to continue this positive approach towards industry, whilst maintaining longer-term objectives.

13. Similarly the Council has also carried out more in-depth analysis of how their research funding and priorities fit in the Foresight objectives[12]. We would urge that, following future rounds of Foresight, all Research and Funding Councils should adopt a similar approach.

14. CBI members continue to note that, despite the 1993 White Paper and the Foresight programme, it remains difficult to see the co-ordination of spending across Government. Even within the Office of Science & Technology it is difficult to see who maintains an overview of the science budget—the Director General of the Research Councils or the Chief Scientific Adviser, who is also "Head of the OST".

15. The CBI has and continues to believe that Foresight can further develop its role of co–ordinating the significant investment in research across Government, as well as build on the success of enhancing the dialogue between Government, universities and industry. The current consultation on the future shape of the Foresight programme is an opportunity to achieve these objectives.

16. The views of the CBI on the funding of high quality research in our science base have previously been presented to the Committee [13]. We continue to have concerns that our leading research establishments are not supported to cover the full cost of their research and that this will lead to problems in the future.

17. However there is also an issue on the exploitation of new ideas and technologies by local SMEs. We believe that a third leg of funding—bringing together appropriate resources of the DTI, Funding and Research Councils, along with the Regional Development Agencies in a pivotal role—is required to translate technology and enhance mobility into companies that would not otherwise consider innovation as a priority. This will only be effective if aligned with professional recognition by those university departments and academics fulfilling this role.

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[11] *Case for the Continuation of the First Five PTPs,* AIRTO Paper 96/3.

[12] *Action for Foresight Engineering and Physical Science Research Council, May 1998 (ISBN 1 899371 427).*

[13] *The Implications of the Dearing Report for the Structure and Funding of University Research:* Memorandum by the Confederation of British Industry to the House of Commons Science & Technology Committee CBI, October 1997.

CONCLUDING REMARKS

18. The CBI remains concerned about the less positive attitude expressed by UK domestic companies towards innovation. Innovation is about the successful exploitation of new ideas. The majority of companies in this year's Innovation Trends Survey reported that gains in business performance, especially gains in sales revenue and new customers, was most likely to occur from the more recent innovations. It is all the more worrying therefore that the UK still has some way to go to improve its attitude and performance on innovation.

*June 1998*

## APPENDIX 21

**Letter to the Clerk of the Committee from Mr Graham Watts, Chief Executive, the Construction Industry Council**

Thank you for your letter of 27 January 1998 inviting the Construction Industry Council to submit a memorandum of comment addressing the points raised by an inquiry into Innovation and Technology Transfer in the fields of engineering and physical sciences being conducted by the Science and Technology Committee.

As you may know, the CIC is the representative forum for all the professional bodies in the construction industry, collectively representing over 350,000 individual professionals and over 19,000 firms. It was formed in 1988 and its principal objectives are to promote improved value for clients and to encourage unity in the construction industry to emphasise its significance in the nation. A full list of members is attached.[14]

CIC, in conjunction with the Construction Research and Innovation Strategy Panel (CRISP) - an industry/government panel, seeks to promote the exploitation and application of innovation and research in the construction industry and achieves this principally through its Innovation and Research Committee. CIC has provided input and advice to the CRISP submission to the inquiry and is pleased to support the CRISP Memorandum[15], which I understand has been received by you.

I would be pleased to provide further information and advice as required by the inquiry and trust you will not hesitate to contact me should you wish.

*11 March 1999*

## APPENDIX 22

**Memorandum submitted by the Construction Research and Innovation Strategy Panel (CRISP)**

INTRODUCTION

1. The Construction Research and Innovation Strategy Panel (CRISP) is an industry/government Panel which exists to promote the exploitation and application of innovation and research in construction and associated industries. It brings together users, funders and providers of research from across the industry and its clients. It aims to identify, prioritise and facilitate research to support innovative thinking and to encourage its application to promote cultural change and delivery of client value. CRISP is funded by the Construction Sponsorship Directorate of DETR and also enjoys active participation by the Highways Agency and Engineering and Physical Sciences Research Council, who seek the benefits of a co-ordinated research strategy for construction. This response is submitted on behalf of the industry members of the Panel. Its mission statement is at Annex A[16] and a background note and constitution at Annex B & C[16].

SUMMARY

2. CRISP believes that the achievement of significant improvement in the productivity, cost effectiveness, quality and environmental impact of construction in the UK requires major change in the processes by which construction businesses operate. Improved productivity, efficiency and competitiveness require the appropriate application of research to support innovation, which requires the maintenance of a strong science base in the universities and research organisations. CRISP believes that there is a significant need for more effort to be focused on transferring research outputs into practical applications and tools for practitioners, through schemes such as the Construction Best Practice Programme and collaborative industry led research programmes.

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[14] *Not printed.*

[15] See below.

[16] *Not printed.*

SUBMISSION

3. CRISP was established in response to a review of government sponsorship of the construction industry, which, amongst other things, recommended that:

"...the dissemination of research results to the industry needs to be improved".

4. CRISP was given responsibility for advising the then DOE on Industry priorities for research and innovation. Since its formation as an industry/government Panel in 1995. CRISP has contributed significantly to:

— the introduction by the DETR of Business Plans which set out the rationale for its Construction Research Programme and set out the basis for adjusting the current balance of research funding.

— the EPSRC restructuring of its Engineering Programmes and the formulation of the EPSRC Business Plan for 1998–99.

5. CRISP welcomes these moves to clarify the strategy, role and purpose of these funding programmes. The Panel recommend that these new arrangements are now allowed to develop for a reasonable period before further significant changes in the funding arrangements and the balance of funding for research and innovation are proposed. The Panel notes that in some sectors funding decisions are made on a longer term basis than in the construction related sectors.

*Industrial Application of Research & Role of EPSRC*

6. The Panel recommend that there is significant scope for improved application of research and dissemination of research outputs, particularly from the university sector. It is aware of the efforts which EPSRC and DETR are making to address this issue. There is also a need for the industry to learn more from other industry sectors. This can in part be addressed through existing programmes, such as the Technology Transfer Secondment Scheme or the proposed PRAISE (Placing Research Assistants in Industrial Secondments) scheme. It will also be addressed by placing even greater emphasis on the application and implementation of outputs.

7. In the construction sector this will also be addressed by the Construction Best Practice Programme, a new initiative funded by the DETR and run jointly with the Construction Industry Board, which has arisen from the work of CRISP. The Best Practice Programme seeks to foster improved use of existing research and innovation in the construction sector, including the provision of exemplars and case study demonstrations. EPSRC are also placing greater emphasis on the application of research, and the Panel welcome this.

8. The Panel recognise that as well as providing knowledge to help the industry to innovate there is also a need for a cultural change within the industry to increase its desire to innovate. This issue does not appear to be addressed in the committee terms of reference, but the Panel believe that this is a fundamental issue to greater application of research in the construction industry.

*Independent Research Organisations*

9. Industry owned research organisations are also a focus for collaborative research and the dissemination of technical process and market information. They often play a key role in their members' development of new products and services, particularly in the case of SMEs. They do this by:

— undertaking research and dissemination programmes to motivate innovation and the application of knowledge;

— helping their industry to keep abreast of technical and market trends thereby assisting them to justify the development of a new product or service;

— providing immediate access to technical information or an expert to assist in the development process;

— provide independent product testing to stimulate market confidence and demand; and

— disseminating knowledge of the product or service through their information services.

10. There are now no government laboratories operating in the construction sector.

*Collaborative Programmes*

11. Industry members of CRISP support the DETR programme of funding for collaborative research involving industry and research organisations, Partners in Technology, the EPSRC Innovative Manufacturing Initiative and the jointly funded LINK programme. These contribute to improved application of Government-funded research in the construction sector and promote industry led collaboration in research. CRISP believes the LINK programme would benefit from clarification of the rules governing the availability of funding to research organisations.

12. Industry is, however, concerned at the increasing complexity of the process for obtaining government support and at the length of time to obtain funding for work when product development cycles are becoming increasingly short, particularly where IT systems are involved.

13. Company strategy, which is driven by market factors, is the key to encouraging greater innovation. Innovation will be supported when it contributes to the achievement of the overall strategy. This will often require short term research work. Government funded research programmes, whilst they do not directly support individual company plans, create a supportive climate for research and innovation, promote an innovative culture and provide a reservoir of completed research and a skilled research base on which industry can draw, sometimes at very short notice. This is essential to the ongoing competitiveness of the industry. In particular, the industry research organisations are a key resource for the industry and provide a wide array of triggers to further innovation.

14. Construction is a sector which is heavily regulated. Regulations address planning, construction, including both design and site activity, health and safety in use and fire regulation. The 1981 White Paper on "The Future of Building Control in England and Wales" noted that the form of the Building Regulations then in force "is inflexible for many purposes, inhibits innovation and imposes unnecessary costs." This observation may be more widely applicable—excessively prescriptive regulation can fossilise technology and practice by forcing everyone to do something in a particular way. On the other hand, a regulation that sets a performance standard beyond current practice ought to have the effect of accelerating the introduction of new methods. In response to the ideas set out in the White Paper, the Building Regulations were extensively recast in the 1985 revision, moving away from prescription towards performance specification where possible. CRISP endorses the view that regulation should be performance-based rather than prescriptive and that consideration should be given to possible impacts on innovation when regulations are made or revised.

15. Within construction, much activity is governed by codes, standards and regulations. These have fundamental influence on the manufacture and use of construction materials. Changes in practice brought about through changes in regulations or standards often benefit a very wide constituency and assist government in achieving policy objectives. It is important that the research needed to underpin the development of codes and standards continues to receive government support, and that the independent industry research organisations continue to be funded to play an independent role in the development of standards, codes and regulations.

*Financial Support for Application of Research*

16. The primary providers of information and the application of research in the sector are the industry research organisations. These depend on government programmes for support for their work, as detailed above. These programmes provide a wide range of research of a non-proprietary nature, such as that currently funded by the DETR and EPSRC programmes. Much of this research is of benefit to the public or supports government policy objectives and statutory duties and is most unlikely to be funded by industry. Continued support that is clearly focused on improved application of research and technology transfer is important for the industry.

*Foresight and Networks*

17. The Panel co-operates closely with the Foresight Construction Panel and is contributing to the development of its plans for the next Foresight exercise. The Panel itself provides a network which supports research and innovation activity within the industry, and there are a number of other networks which operate in various segments of the construction industry. These provide important informal opportunities for transfer of knowledge in a format and context which is compatible with, for example, Continuous Professional Development arrangements.

*11 March 1998*

## APPENDIX 23

### Memorandum submitted by Cranfield University

1. Introduction

1.1 Cranfield University welcomes the opportunity to give its views on Engineering and Physical Sciences Based Innovation. Cranfield presently has the largest earnings from UK industry of any British University by a substantial margin and also, presently, operates the Teaching Company Directorate on behalf of the Department of Trade and Industry. The University therefore has a significant background of relevance to the inquiry. The author, Professor P Hutchinson, was a member of the Working Group which prepared the response by the Royal Society to the Inquiry and is in full agreement with the observations made there. This response will only add matters that are not dealt with in the Royal Society submission so as to avoid burdensome repetition.

## 2. Summary

2.1 Engineering and Physical Sciences Based Innovation is a complicated process the components of which are now beginning to be elucidated. This clarification could facilitate stimulation of innovation.

2.2 Government laboratories and independent research and technology organisations have a clear role to play in innovation and technology transfer but can suffer from difficulties associated with inadequate outlets for ageing researchers who lose productivity in research.

2.3 The undue focus of the Research Assessment exercise on publication in referreed journals and the relatively low weight attached to research for direct application diverts some of the most able researchers away from innovation.

2.4 The conclusions formed in the Foresight process should be updated and reviewed on a regular basis less they become ossified and irrelevant to current business.

## 3. Innovation and Technology Transfer

3.1 Industrial growth means change and more than ever technological change. Widening European and World markets has brought to companies a demand for innovation for more technologically based up-to-date products and more technologically based competition. There are, of course, a number of routes and strategies to help companies acquire technological knowledge. These include: in-house R&D, technology transfer, licence agreements, direct purchase, joint venture projects, company acquisitions and mergers, contract R&D, new personnel and turnkey projects. Each of these has its advantages and disadvantages, but some of the disadvantages of the more formal arrangements include their one-off nature, the time needed to find and choose appropriate partners, lengthy negotiations and often a lack of follow-up support. Indeed it is these difficulties in traditional formal approaches that have, in part, led to the recognition that the search for and acquisition of technology knowledge should be a continuous process rather than a series of one-off periodic steps.

3.2 It has long been recognised that a key characteristic of technologically progressive firms is their high quality of incoming information. As long ago as 1959, Carter and Williams reported the importance of this in almost 200 firms over a wide range of industries. Many other studies have since demonstrated the value and importance of external information for successful technology development and innovation. For example, SPRU's Project SAPPHO confirmed the need for high quality external linkages, as did Peters and Waterman (1982) and CEST (1990 & 1991). Innovation in companies is now being scen as an on-going process of know-how accumulation based on a complementary mix of in-house R&D coupled with a proactive searching and scanning of technology based knowledge developed elsewhere (Cohen and Levinthal, 1990; Seaton & Cordey–Hayes, 1993; Trott, Cordey-Hayes & Seaton, 1995).

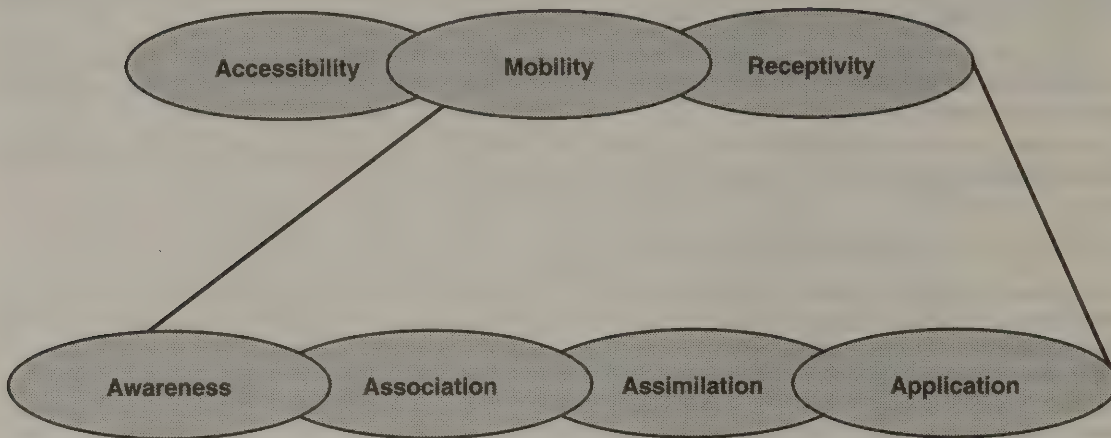
3.3 This process of search and acquisition of technical information being practised by technologically progressive companies often involves informal networks, partnerships, and formal strategic alliances.

3.4 A relevant background question is to ask how this practice can be extended more widely to less technologically advanced organisations and to SME's without an R&D activity.

3.5 To assist such organisations in this process, there has been the evolution of a number of Intermediaries or third parties who aim to aid this knowledge transfer process. These include RTO's, Regional Technology Centres (RTCs), specialist transfer agencies such as Defence Technology Enterprises, and more recently one-stop-shops such as Business Link and the major activity of the Foresight Programme. The performance of these have had a mixed success. Partly this has been because of the emphasis they have placed on making provision of technology ideas, on the assumption that increased exposure to these ideas would in some way result in beneficial technical change in industrial companies. While such provision of "access" to technological ideas is an important and necessary part of technology transfer, it is only one component of a much more complex process.

3.6 The conceptual framework shown in Figure 1 attempts to illustrate technology transfer more realistically as a series of interacting sub–processes, rather than a simple one–off transaction or decision process. This framework was initially developed following a study of the role of intermediaries in which a mismatch was identified between the needs of potential innovators and the activities of information–centred technology transfer agencies. The research revealed that where much effort appeared to have been devoted to providing "access" to technology knowledge, little effort had been aimed at understanding the needs of organisations acquiring technology knowledge developed outside their own organisation and the transfer channels appropriate to them.

**Figure 1 Conceptual frameworks for technology transfer**




3.7 The illustration in Figure 1 is considered to provide an appropriate vantage point from which to explore the issues involved in innovation and technology transfer. But firstly, it is necessary to define terms:

*Accessibility:* the level of technology knowledge and the availability of related information

*Mobility:* the ease of obtaining this technology knowledge and the appropriate channels (eg intermediaries, people movements, networks, partnering) through which technologies are transferred)

*Receptivity:* an organisation's overall ability to be aware of, to identify with and to take effective advantage of technology.

3.8 Any investigation of technology transfer should take account of mobility channels and varying levels of receptivity as well as taking account of levels of technology accessibility.

3.9 Finally, the remaining terms in Figure 1 need clarification and this can be achieved by expanding the definition of receptivity into a process of search and information acquisition. Thus, receptivity is the capacity of preparedness to:

— search and scan for information which is new to the organisation (awareness)

— recognise the potential benefits of this information by associating it with internal organisational needs and capabilities

— communicating these to, and assimilating them within, the organisation

— applying them for competitive advantage

3.10 The paper "Inward technology transfer as an interactive process" by Trott, Cordey–Hayes and Seaton develops these concepts further and is based on studies conducted within ICI Chemicals & Polymers Ltd.

## 4. The Industrial Application of Government Funded Research

4.1 The industrial application of Government funded research should be taken much more seriously in the UK than it is presently. This is probably a significant factor influencing UK economic performance.

4.2 Many Government measures presently miss the mark by taking either an over simple view of the process of technology transfer and innovation (see above) or by positively obstructing it. For example, the undue focus of the Research Assessment Exercise on publication in refereed journals, and the relatively light weight attached to research undertaken for direct application, diverts some of the most able researchers away from innovation and into publishable research.

## 5. The Respective Roles of Government Laboratories and Independent Research and Technology Organisations

5.1 These organisations have a clear role to play in innovation and technology transfer. However, they suffer from a key difficulty in that there is no clear onward route for those researchers who, as they age, cease to be productive. By contrast, the Universities have a continuing flow of bright young people committed to research who move through the process of PhD research into post-Doctoral positions and on into Industry and Commerce. It would be useful to find an appropriate association between the Universities, Government

Laboratories and independent research and technology organisations. The EPSRC Partnership scheme is a useful example. It might be useful to re–adjust the terms of employment in Government research organisations and independent research and technology organisations so that a relatively small number of people, of established productivity, have permanent appointments, together with a larger group who move through employment in research into employment in the commercial and industrial sectors.

6. The Operation of Government Schemes Designed to Promote collaboration in and Industrial Application of Research

6.1 There are now many Government schemes designed to promote collaboration in, and industrial application of, research. Much is made of collaboration in many of these schemes, but more often than not they remain firmly focused away from genuine application and exploitation. In order for exploitation and application to occur, the collaborations must be of long duration. Regrettably, many of the schemes have a too near term focus.

7. Intellectual Property Rights and Patenting

7.1 See the observations in the Memorandum from the Royal Society.

8. The Provision of Finance to Support Enterprises in the Application of Research and Innovation

8.1 See the observations in the Memorandum from the Royal Society.

9. The Role of the Foresight Programme in Fostering Networks and Identifying Priorities

9.1 The Foresight programme was successful in fostering networks but, if this was the aim, it could have been achieved more directly and at much lower cost. The support provided to at least one panel, of which the author was a member, seemed inadequate and there was a consequent tendency to waste the time of panel members. In future exercises this effect would be modified if the panel members, or their institutions, were reimbursed the full cost of members' time.

9.2 The conclusions formed in the Foresight process should be updated and reviewed on a regular basis, lest they become ossified and irrelevant to current business. There is reason to doubt the generality and soundness of some of the conclusions.

10. The Role of the Engineering and Physical Sciences Research Council in Fostering Technology Transfer

10.1 See the memorandum by the Royal Society.

11. Progress Made Towards Implementing Those Recommendations of the Science and Technology Committee in the previous Parliament in their report on "The Routes Through Which the Science Base is Translated into Innovative and Competitive Technology relevant to the fields of Engineering and Physical Sciences"

11.1 See the memorandum by the Royal Society.

*2 April 1998*

## APPENDIX 24

### Memorandum submitted by K Marjorie de Reuck

1. Introduction

1.1 I have been a member of the International Union of Pure and Applied Chemistry (IUPAC) Thermodynamic Tables Project Centre since its inception and recently retired as its Deputy Director. The Centre has been at the heart of the development of internationally approved reference standard equations of state for industrially important fluids for more than 30 years and has published 13 volumes in the series "International Thermodynamic Tables of the Fluid State" (see Appendix 1)[17]. The Centre has been recognised as a leader in the promotion, analysis and dissemination of high quality experimental data for the thermophysical properties of fluids. Two major computer software packages have been developed which provide accurate equilibrium thermodynamic and transport property values for pure fluids and mixtures for

[17] *Not printed.*

industrial needs (see Appendix 2)[18]. The international collaboration enjoyed by the Centre has provided it with a comprehensive knowledge of the work carried out world–wide and has enabled it to influence the experimental programmes of work in laboratories throughout the world.

1.2 An adequate knowledge of the thermophysical properties of all gas and liquid components involved in proposed new industrial processes is required for successful innovation.

## 2. Summary

2.1 The oil, gas and chemical process industries, power generation and refrigeration industries as well as the food, fine chemical and pharmaceutical industries cannot innovate successfully without an adequate knowledge of the thermophysical properties of all the gas and liquid components involved.

2.2 Research, experimental capabilities and teaching resources which are available in this field in UK universities, industry and Government laboratories have declined drastically in the past 20 years or so.

2.3 International endeavour in the area of thermophysical properties is not large, therefore it is important for the UK to collaborate with existing work elsewhere and to reinvest in our own skills base.

2.4 In order to begin to rebuild a viable network of skills, research and information the first requirement is for funding for a network among the few groups which remain within industry and academia in the UK.

2.5 All Foresight Programmes should consider the needs for adequate data within their area of expertise.

## 3. Requirements for Thermophysical Property Data

3.1 The industries referred to in para 2.1 use many pure components and mixtures in both the liquid and gas phase. In order to innovate and to design efficient and environmentally-friendly processes the thermophysical properties of these fluids must be known with an appropriate accuracy.

3.2 The thermophysical properties required include all the equilibrium thermodynamic properties as well as the transport properties both for pure fluids and for mixtures. Adequate predictions of the phase equilibria of mixtures which may contain many individual components are particularly important; failure to do so may result in missing a potentially profitable innovation or in developing a process which falls below the expected returns on investment.

3.3 Since it is impractical and prohibitively expensive to measure all properties for all materials of interest, accurate predictive schemes are essential, both for innovation and development of new processes.

3.4 International research is in progress which uses the high accuracy pure fluid equations of state given in Appendix 1[1] to improve the prediction of mixture properties; this work is handicapped by a lack of data on mixtures of sufficient accuracy to enable the new models to be rigorously tested.

## 4. Facilities

4.1 Research facilities in this area, together with the accompanying highly skilled personnel, within UK universities, have seriously declined in recent years; some departments have closed and others have diminished; there are few researchers being trained at postgraduate level.

4.2 There is no Government Laboratory which specialises in the measurement of thermophysical properties of fluids; the National Physical Laboratory (NPL), some 15 years ago, closed its own group which had international expertise in the measurement of properties such as vapour pressures, saturated densities and heat capacities of liquids. The National Engineering Laboratory (NEL), historically strong in the area of measurement of the thermophysical properties of fluids is much reduced in size and is now privately owned.

4.3 The recent downsizing, outsourcing and restructuring exercises by many major oil, gas and chemical companies have greatly reduced their thermodynamic capabilities in both measurement and prediction and instead they now rely on software packages provided externally.

4.4 There are dangers in this approach[19]: computer prediction packages, although robust, are not entirely reliable, therefore it is essential, for the sake of safety, efficient process design and the ability to innovate successfully, that users are experienced and knowledgeable in the field.

4.5 Following the downsizing of many companies the age structure of their remaining thermodynamically experienced staff is often now very narrow. Too small a base of expertise leaves companies vulnerable: a level of expertise is required, not only to perform the tasks required in-house, but also to be able to innovate and to take advantage of technological developments which occur elsewhere in the world.

4.6 Networking is essential to make full use of the few facilities and scarce skills which still remain within the UK. The IUPAC Centre has been functioning as a network node, both nationally and internationally;

[18] *Not printed.*

[19] Carlson, EC, "Don't Gamble with Physical Properties for Simulations," *Chemical Engineering Progress*, October 1996, pp35–46.

recent experience of the number of requests for information suggests that many within industry are not aware of other sources.

4.7 Whilst major multinational enterprises may have access to the necessary skills and specialist facilities world-wide, small and medium sized enterprised (SMEs) will be mainly dependent on their availability within the UK.

4.8 International cooperation is one of the ways forward in this area. The process which is being used to develop the necessary thermophysical property data for the new refrigerants could be taken as an example (see Appendix 3[20]).

4.9 The subject of thermophysical properties of fluids is not "fashionable", but it is a necessary part of the foundation required for successful innovation in a wide range of industries.

4.10 In the foreseeable future industry in the UK will increasingly rely in some areas on inadequate data or predictive facilities operated by a reduced skills base, with consequently retarded rates of innovation as well as increased costs and diminished safety margins.

*9 March 1998*

## APPENDIX 25

### Memorandum submitted by Eastern Group plc

INTRODUCTION

1. Eastern Group is an integrated UK based energy company comprising Eastern Electricity, which distributes electricity to three million customers, Eastern Energy, which supplies gas and electricity to around four million customers, Eastern Generation Limited, the fourth largest UK generator with 6.7 GW capacity and Eastern Power and Energy Trading an energy wholesale and risk management business.

2. Eastern's Networks business has a long-term vision of providing an interruption free network for its customers which can only be achieved through technical innovation. Eastern Generation's profitability depends on maximising plant efficiency and availability whilst complying with environmental legislation. Eastern therefore has considerable vested interest in the application of state of the art technology cultivated through research and development in the engineering sector.

REGULATORY FRAMEWORK

3. The Director General of Electricity Supply (DGES) is responsible for regulating the UK electricity industry through the Office of Electricity Regulation (OFFER). The DGES has a secondary duty "to promote research into, and the development and use of, new techniques by or on behalf of persons authorised by a licence to generate, transmit or supply electricity". This is one of the responsibilities of OFFER's Technical Director but is a low key activity. Eastern concurs with this approach and does not believe that it is a relevant role for an economic regulator. The present regulatory formula does not provide any specific incentives or require separate expenditure on R&D although it incentivises business efficiency through the RPI-x formula and improved network performance through the Guaranteed Standards and the publication of actual network performance.

EASTERN'S APPROACH TO R&D

4. Eastern generally employs only proven technologies in order to comply with network reliability standards and to provide a high level of generation availability. State of the art technology, e.g. hot glove working, pole–mounted auto reclosures and improved lightening protection equipment, has been adopted to improve network performance. In seeking new technologies and innovative techniques for network design, development, construction and maintenance Eastern generally relies on the manufacturers for product development. However Eastern believes it important to work alongside manufacturers to develop improved products and participates in appropriate technology transfer schemes e.g. development of pad mounted substations and metering technology. The introduction of new specialist IT systems and diagnostic inspection techniques has improved fault–finding and monitoring of the network. New products are assessed as they reach the market place.

5. Eastern also invests directly in technology research and development through several establishments (e.g. EATL, ERA and Strathclyde University) based upon its strategic business needs as defined in the Distribution Business which links all business drivers with network activities. This process includes a gap analysis where the plan identifies operational requirements that current techologies cannot deliver and enables Eastern to focus its research activities. However, in common with most other RECs, Eastern does

[20] *Not printed.*

not provide significant funding to develop new products and processes in any engineering field which is outside our core expertise.

6. Eastern no longer contributes to research into end use technology for electricity but focuses on providing innovative solutions and bespoke service packages to its industrial and commercial customers to improve business performance and reduce operating costs. This includes the testing and demonstration of process techniques and identification of the most appropriate technology at Eastern's Industrial Energy Efficiency Centre.

7. Although Eastern has not taken advantage of any UK Government funded programmes it is involved on European funded projects, including joint collaboration.

SUMMARY

8. Eastern embraces the philosophy of using state of the art technology and is actively involved in the transfer of new technology that improves business performance and is required by its customers. To this end Eastern has recently established a Technology Transfer Unit. However research is not a core activity and is best undertaken by dedicated research institutes and manufacturers. Businesses operating in competitive markets will continue to demand innovative solutions, improved technology and new products to facilitate growth. Manufacturers will provide the solutions that the market demands.

9. Eastern believes that the Government has a role in developing "blue–sky" technology that would benefit UK plc rather than individual companies. This must be prioritised and focused on specific activities which the Foresight Programme aims to achieve. Collaboration between public and private sector organisations should be maximised for all Government funded projects which must be tightly managed with appropriate review stages. UK organisations should be actively supported and encouraged to take advantage of available EU funding. An appropriate framework for the subsequent dissemination and promotion of new technological applications and best practice within the market is desirable.

*11 March 1998*

## APPENDIX 26

### Memorandum submitted by the Economic and Social Research Council's Innovation Programme

1. The Economic and Social Research Council is the UK's leading research and training agency addressing economic and social concerns. Among its research portfolio are a series of major investments addressing the crucial role of innovation in sustaining the creation of wealth and the quality of life. One such is the £3.5 million "Innovation Programme" which is concerned with the role of innovative management in the achievement of sustained improvement in the performance of public and private sector organisations and businesses. In particular it focuses on the human and organisational conditions that contribute to this, and a feature of the programme is the close collaboration between academics and "practitioners", including engineering and physical sciences based companies. The academics involved also cover a range of disciplines including engineering.

2. This short memorandum wishes to draw the attention of the Committee to the experience of the programme which is demonstrating very clearly that some of the key business processes involved in the exploitation of science and technology by engineering and physics based companies are not peculiar to them but are common across all business sectors and size of company. These relate particularly to the institution of organisational structures and people management policies which stimulate and sustain a supportive climate for innovation. There is, therefore, much to be gained by taking a much broader view of innovation in engineering and physics based companies than is implicit in the Committee's terms of reference, and the Committee is recommended also to refer to the experience of other sectors in tackling these analogous and core processes.

3. As an illustration of the importance of cross–fertilisation, a few relevant examples from the experience thrown up by the Innovation Programme are now described.

4. A company falling very much within the Committee's interest is Pilkington Optronics, a leading high tech company in the defence sector which is making a major investment in new organisational processes to support an innovative, customer–oriented, production process. A multidisciplinary research team from Lancaster University undertook an analysis of the introduction of new approaches to manufacturing, a study of the problems of introducing and integrating new specialisms into the organisation, and on-line observation of the work of cross–disciplinary design teams. The study suggested that the management of the capture and flow of knowledge within project teams, between them, and in the context of overall company strategy and market positioning are key processes. Assumptions that organisations can be managed like machinery are unlikely to help in complex situations such as those of companies like Pilkington Optronics. It is important for employees in such organisations to be able to engage in learning cycles in which they can question, consider, communicate, model, improvise and reconstruct ideas, and that such learning is properly integrated into organisational activities. The design of the project and the testing of ideas emerging as it proceeded benefited

considerably from the experience of a group of other interested companies including the utilities and chemistry based firms.

5. Also in the knowledge management area, researchers from UMIST looked at how this was done in R&D functions associated with a multi–sectoral grouping involving Hewlett Packard, ICI, Amersham International, British Aerospace and Ove Arup. The information obtained enabled the researchers to come up with a generic audit tool which will provide a much wider population of companies with a basic "health check" to identify where their knowledge management practices are falling below desirable performance levels, and how the shortfalls might be addressed.

6. The audit tool just described is the outcome of one of a number of projects are investigating techniques to assist in the management of the innovation process. Researchers in Plymouth are devising a scenario tool to help managers predict what might be the effects of major organisational discontinuities in companies such as restructuring, takeover, merger etc. While a project based at East Anglia University is looking at the implementation in the UK of the "Hoshin Kanri" management technique. This integrates long-term strategic objectives with daily operations by aligning people with a common focus, and by installing an organisational adaptability so that at any one time, employees at all levels can know where they stand with regard to top policy and what is happening in the external environment. Again both projects are working with engineering and physics based companies alongside companies from the chemical and life sciences and services sectors.

7. The philosophy of partnership between academia and business, catalysed by Government support, underpins the nature of the Innovation Programme and other similar ESRC investments. The Programme is also contributing to the development of policy to support such partnerships, through a series of consultations on how they may be encouraged and sustained. Networking between and among researchers and practitioners is also a strong feature of the Programme with most of the projects having multi–sectoral advisory groups associated with them, such as the Lancaster/Pilkington project described above, contributing to the cross–fertilisation of ideas.

8. The Innovation Programme therefore is a practical demonstration of how the previous Select Committee's thinking (as described in "The Routes through which the Science Base is translated into Innovative and Competitive Technology[21]) is being progressed, particularly those aspects of it relating to the need for a holistic view of innovation, the role of management, the value of networking, and of partnership between Government, business and academia. It is hoped that in its deliberations the Committee will take into account the need for comparisons with this wider experience of common problems.

*30 April 1998*

## APPENDIX 27

### Memorandum submitted by the Environment Agency

INTRODUCTION

The Environment Agency is responsible for environmental regulation and management in England and Wales. In addition to its functional duties linked to environmental protection and water management, it has an overarching duty to contribute to the achievement of sustainable development. In this respect, it is implementing a long–term Environmental Strategy aimed at protecting and improving the environment, while enabling the nation's social and economic base to develop. The Agency also has a duty to carry out research in support of its functions and plays an active role in Foresight. (The following evidence is supported by the findings of Foresight).

SUMMARY

The "environmental imperative" for industry and society to shift towards environmentally cleaner and more efficient products and processes is emerging as a key driver of innovation. This move is increasingly consumer-led, and applies to a wide range of markets. It deserves identifying as a driver in its own right—alongside, but separate from, the more traditional "market pull" and "technology push".

1. With regard to the role of Foresight in identifying priorities, there is evidence that industry is becoming increasingly aware of the "environmental imperative" as a driver of innovation, alongside the traditional "market pull" and "technology push". This applies to a wide range of products in those fields of engineering and physical sciences where traditional production and consumption processes have impacts on the environment, or utilise resources, to a degree which is unsustainable. This "environmental imperative" is driven by the fact that environmental pollution and consumption of natural resources are accelerating as both global population and wealth per capita increase.

2. The accelerating pace of change calls for innovation to further sustainable development—the challenge is to do more with less. (This is a central plank to Government's strategy for Sustainable Development). This means developing and introducing cleaner and more efficient technologies. For example, both agricultural

[21] First Report, Session 1993–94 (HC 74).

and industrial production needs to encourage cyclical resource–efficient processes rather than linear processes which give rise to a higher level of waste.

3. The critical driver of the "environmental imperative" is stakeholder pressure (from shareholders, customers and the general public). Public concern is particularly high over health related issues.

4. In terms of response, Government needs to promote the direct use of economic instruments to discourage the use of scarce resources and/or adverse impact on the environment. This would include incentives and disincentives to encourage a more sustainable national economy, and cleaner and more efficient industrial processes and products. In particular, the Government should consider means of providing more support for the development (as distinct from research) and demonstration of these clean and efficient science and technologies. A critical "innovation gap" exists here.

*9 April 1998*

## APPENDIX 28

### Memorandum submitted by The Gatsby Charitable Foundation

Engineering and science based innovation: a response to letter of 15 December 1998

SUMMARY

This note sets out various models of which Gatsby is aware. These include:

(a) University innovation companies;

(b) University–based bursaries: these may be linked to one department allowing it to develop industrially relevant products and processes, or it may allow members of staff to be released from their other duties to take forward an innovation to the point at which the company could be spun off with seed funding;

(c) Inter–university: where a number of universities join together in one particular technology;

(d) Regional: where a number of universities join together in a particular region working closely with the region's industry.

(e) Commercial and independent technology transfer companies which would be outside the remit of Gatsby.

A Fraunhofer–like model was developed between BHRA and Cranfield about twenty years' ago and more recently has appeared in the form of Faraday centres. The teaching company scheme clearly provides a similar model.

Gatsby is encouraging similar developments through Cambridge University's Institute for Manufacturing which complement the University's strength in manufacturing and industrial links.

Key to all of this are the individuals involved, and the need to identify, groom and encourage suitable individuals is at the heart of the Gatsby funded Royal Academy of Engineering education Continuum. In particular there is a need to encourage management skills in life scientists engaged in industrial developments.

In addition, the Trustees: have commissioned an evaluation of the technology transfer initiatives they are funding; have run jointly with CVCP a workshop on key issues; have provided funding for a delegation from CVCP to visit the USA to identify lessons that can be learned from there.

1. BACKGROUND

The Foundation has given a clear steer of its interest in supporting academic institutions to help them restructure so as to relate more effectively to the non–academic world.

Their interest in technology transfer is a logical development of their initiative at the John Innes Centre. Plant Bioscience Ltd (PBL) is a technology interaction and intellectual property management company, working in the field of plant biotechnology. Established in February 1994, it is jointly and equally owned by Gatsby and the John Innes Centre. Theo do Bock (Chief Executive Officer of PBL) has been key to the early success.

There are other possible models for technology transfer and it is unlikely that there will be a single "best" model. Some are:

(a) *University based*

Many universities have industrial liaison and technology transfer units. Their effectiveness is very varied and is likely to be dependent on the individual heading the unit and his/her fruitful collaboration with lively groups within the university and ability to relate to industry, especially to medium sized firms. There is a serious suspicion that such units may confuse the industrial sponsor, be seen as superfluous to lively

engineering departments which are already working with industry, and may actually inhibit industrial liaison. It is clearly essential, therefore, in any development, that the details of the unit are right. Gatsby has provided the funding for Southampton University to develop such a free–standing company which has good links with the ILO office and appears to be achieving success.

(b) *University based, but linked to one department or one technology*

The chances of success may, in some cases, be greater where linkage is with one department or one technology, since the department owns the activity and the head of department is likely to be the chairman of both the academic activity and the technology transfer activity. In this case the unit will be able to confine itself to one technology and to liaise closely with the department to ensure that existing academic/industry links are not upset. PBL Ltd appears to be a good example of this approach. However, the flow of income (royalties or a percentage of sponsored research costs) may not be sufficient to cover the running costs of the technology transfer organisation if based on a single Department. (Some experts estimate that research expenditure of £20 million per annum is the minimum necessary to provide a viable business).

An alternative approach is being tried at Nottingham University - in their Chemistry department. Funding from Gatsby underwrites the salary of an industrial links fellow enabling industrial applications of super critical fluids to be developed.

(c) *Inter-University*

A centre which links one technology across several universities could be a very fruitful approach in that it allows industry to identify the most appropriate university for its needs, and encourages collaboration between universities so that they develop their strengths and are less tempted to duplicate what is already happening elsewhere.

Calyx Plantech Ltd, a joint universities business development for plant science, is such a development bringing together the universities of Leeds, Warwick, Birmingham, York, Glasgow and Manchester.

The company's first objects clause is: the furtherance, cultivation and promotion of plant science and learning by facilitating and enabling universities to:

(a) identify, protect, publish or otherwise enable exploitation for the public benefit of relevant intellectual property;

(b) secure funding for plant science;

(c) foster beneficial relationships between universities and commerce and industry.

Gatsby has provided grants to the participating universities to initiate this on condition that they put in their own funds also. The success of this venture has yet to be proved.

(d) *A regional initiative to enable universities to contribute to the development of a region*

This is similar to (c), but concentrates on one geographical region. It would have the merit of a geographically coherent group of universities serving local industry, but obviously not confined to local industry. As with all these ventures success is heavily dependent on the right people with the vision and energy to take it forward.

(e) *Commercial and independent technology transfer company*

This would not normally be charitable, nor necessarily single discipline. Some Science Parks and other organisations fall into this category and enable small start up businesses to develop with support from the infrastructure of the science park.

This may also offer the most effective way for large companies to spin off SMEs dedicated to new developments. Small companies are often a more fertile ground for new products, and may still be bought back by the large companies at a later date.

This could not receive Gatsby's support (being a charity).

It is clear that any successful development will depend critically on the person appointed to lead it and on the willingness of the university staff and the research scientists to work together.

2. Fraunhofer Model

Various initiatives in this country have some similarities to the, apparently, very successful Fraunhofer model.

Cranfield has pioneered very strong industrial links at all levels from new technology innovation to the supply of sound engineering consultancy to industry. With BHRA (on the Campus) it set up the Fluid

Engineering Unit which built a successful interface between this Contract Research organisation and the University - providing consultancy, training and effective technology transfer.

The Faraday centres appears to offer a similar model.

The Teaching Company Scheme provides, in many cases, very good linkage between university staff know–how and industry.

Gatsby is exploring another, somewhat similar, approach. This is based in Cambridge Engineering's Manufacturing Institute. It complements other valuable mechanisms already in place in Cambridge. As well as funding for two manufacturing courses, the Advanced Course in Design Manufacture and Management and a new Leaders Programme at Cambridge, Gatsby has provided for the setting up of an Industrial Links Unit. This unit will have, as its initial objectives:

- developing the database of industrial links across the manufacturing group
- co-ordinating and administering the industrial events and meetings already happening and starting up
- providing an industry–friendly single contact point where industrial needs and requirements can be handled efficiently.

The Unit has linked to it various industrial clubs. One new one is bringing together instrumentation companies. The team involved with this club has so far visited over fifty companies and identified, with the companies, problems in manufacture and technology which can either be undertaken as a student project, or as a project for a research engineer. To provide this varied service the Instrumentation Group has recruited a research engineer. The strength of this approach is that through the manufacture and production functions Cambridge can gain the confidence of the company, and with the company can start to define future markets and products. The expertise for the products may come from Cambridge or elsewhere.

Gatsby is also exploring the development of:

(a) matched funding for Cambridge researchers working with industry;

(b) training for entrepreneurs jointly between Cambridge university institutes of manufacturing and management and a local incubator;

(c) training of master technicians with Greenwich University, two FE colleges and others.

These are in their early days but are exciting possible models for the future encouragement of entrepreneurship and innovation.

### 3. Encouraging Early Leadership and Responsibility

With the Royal Academy of Engineering Gatsby is exploring the possibility of a placement programme for very bright engineers and biotechnologists to encourage them into either setting up their own company to develop new and innovative technology or moving into positions of early responsibility. The scheme will enable those involved to develop their skills and careers appropriately at the same time. Collaboration with high technology consultancy and other industrial companies together with incubator centres should result in the first placements.

This initiative highlights a key recognition by the trustees: that most of the success of technology transfer rests with the identification of the right people.

### 4. Evaluation

The trustees would like to obtain more information on successful university technology transfer and the ingredients for this. They also consider that benchmarking would help assess relative success and would also be useful to the universities. They have commissioned an evaluation of the initiatives which they are funding.

### 5. Technology Transfer Workshop: 23–24 January 1998 (in collaboration with CVCP)

At this workshop, these and other initiatives were considered and a brief report has been produced to identify possible actions resulting from the workshop.

### 6. CVCP delegation to the USA

Gatsby provided funding for a group of VCs and directors of university industrial liaison units to visit MIT, Harvard, Boston University, University of California at San Diego and San Francisco, Caltech and Stanford. A report has been produced by CVCP.

*3 February 1999*

## APPENDIX 29

### Memorandum submitted by GEC ALSTHOM Ltd

INTRODUCTION

1. GEC ALSTHOM Ltd is the UK operation of the GEC ALSTHOM group, which develops, designs, and manufactures advanced equipment and systems for the electricity supply and rail transport industries. World–wide the group employs (1996–97) some 94,000 people and has a turnover of around £7.5 billion. In the UK it has about 21,000 employees, a turnover of £1.5 billion, and undertakes at specialist research centres in Stafford, Lincoln and Whetstone, an important part of the group's total worldwide R&D activity of some £300 million annually. In the last ten years its markets have been transformed due to progressive introduction of competition amongst its previously national monopoly customers. It now competes internationally against a small number of powerful multinational competitors on the basis of product performance, cost, and commercial offer.

SUMMARY

We present below our comments on the specific points the Committee is addressing. In general our industry does not depend upon Government executed research as a source of innovation but does use the engineering science base it supports. Schemes for collaborative research are of value, but the Foresight Programme has been less successful than we hoped. Mechanisms to undertake large-scale demonstration of innovative technology have become more scarce, and their absence hinders developments.

COMMENTS

1. There is effectively no application of Government–funded research within our products.

2. Government laboratories have, and continue to, provide certain basic "engineering infrastructure" information to UK industry such as data for standards but do not supply any of the essential technical information used in the design of our products. Such support is, of course, essential to any developed manufacturing economy.

3. Independent research and technology organisations are not sources of product technology for us, and we make virtually no use of their services. This should not be taken as a criticism of their individual capabilities, which may well be of more use to smaller companies. As a large enterprise however we are able to maintain internal expertise in those areas of importance to our business.

4. We have and do take part in certain schemes operated by the Government whose aim is to encourage collaborative applied research. Our reasons for so doing include collaboration with specialist organisations with complementary expertise to our own, the sharing of risk in medium and long-term developments of uncertain technical outcome, and the added-value of working with others who can bring different perspectives to the planning and progress of specific programmes.

5. We feel nevertheless that certain aspects of the management of such Government schemes could be improved. The procedures involved in forming consortia, preparing and submitting proposals, and responding to the resultant queries and criticisms are very resource-consuming, and usually involve an elapsed time that we feel is excessive. An improvement in this aspect would be welcomed by prospective participants and potentially increase the take up of the schemes, in a world in which lead times have shortened dramatically in recent years.

6. In conjunction with these comments we must add that for our industrial sector, which is well–established and mature, we perceive that R&D funding from Government is less available than in other countries. As a specific example a consortium of ourselves and three other major UK companies were negotiating with DTI for support of developments in high-temperature superconducting devices over a period of eighteen months. Eventually DTI decided that funding was not available for this subject. Consequently, the work is now supported and undertaken elsewhere in countries in Europe.

7. Intellectual property rights (IPR) are increasing in importance to our company as a result of the growth in international competition. When our products were tailored to national monopolies they were intimately involved in their design to ensure they met local needs, and overseas suppliers were not considered. Consequently IPR were rarely a consideration. That situation has now changed so the need to avoid IPR infringement is paramount and the ability to secure IPR ownership through various instruments such as patents is a prime factor in the development process.

8. The Foresight Programme has had very limited impact on either deciding or communicating innovation priorities. For those directly involved in the Panels or working groups, which includes employees of our company, there have been some gains in influencing conclusions or in extending our networks of contacts. It is difficult to identify any area in which we have gained information or insight as a result of the process however. For industry at large in the UK who have not been personally involved in the bodies created it appears to us that Foresight has failed to have any effect upon their operation or decisions.

9. It may be that in its present form the Foresight Programme is too large in scope, and attempts to respond to too many interest groups, to define any genuinely focused strategy for innovation. As a means of debate it has the real involvement of too few people to achieve more than could be done by seeking views of expert individuals or companies. It may be helpful to consider alternative approaches such as that followed in the USA where there is focus on topics considered politically to be of national strategic importance. The Presidential task force on Energy consulted hundreds of experts to produce a genuinely authoritative report, published in November 1997, that will guide specific innovation actions.

10. The Engineering and Physical Sciences Research Council is perceived to have a prime responsibility to maintain the scientific base within the Universities, and it is with the latter that we have direct contact. Technology transfer is effected through research contracts placed directly with Universities (typically around £1 million each year), which feed directly into the design data, rules, and methodologies that are critical to the design of our products. We include in this Teaching Company Schemes and CASE awards which we find highly effective mechanisms. There are also consultancy arrangements with specific academic experts (usually as part of such contracts) which is a broader form of technology transfer, and finally the recruitment of typically twenty-five people each year following postgraduate education enabled by EPSRC. The latter is the most effective transfer for us, providing personnel who bring with them awareness of the most current engineering science.

11. Our products are typically of large scale and designed to work as part of a national infrastructure. In their development a critical feature is demonstration of performance which can often be done only "in the field" and at a large scale. With the disappearance of monopoly operators who shared responsibility for innovation we increasingly lack in the UK the facilities to undertake these demonstrations, which can inhibit the ability to take innovative developments through to the stage of international marketing. We believe that the UK, nationally, is increasingly at a competitive disadvantage internationally in this respect.

*10 March 1998*

## APPENDIX 30

### Supplementary Memorandum submitted by The Generics Group plc

RESPONSE TO QUESTIONS FOLLOWING THE ORAL EVIDENCE SESSION

1. We have not had any particular problems with the European Patent Office except for some inconsistencies between the various language versions of the same patent. Many SMEs find their charges very high. In terms of improvements to the service, we would suggest that free access to patent searches via the WWW be available, as is the case with the US equivalent. Members of the Committee may wish to look at the IBM patent server web site (www.patents.ibm.com) to see what can be done.

On a more general point, there would be an advantage if certain information services such as Dialog were made available to SMEs either free or subsidised.

2. The effective exploitation of IPR varies according to sector, with comparable performance in most parts of Europe. The pharmaceutical and life sciences sectors are very good, but the universities are generally poor compared with their US counterparts.

3. I do not believe that poor quality management (as a formal, documented, process) is of itself a limitation to growth in comparison with other factors presented in our submission. On the other hand, it is essential that SMEs adopt the quality standards of their marketplace set by larger companies if they are to succeed. Customers within a marketplace do not see smallness as an excuse for low quality. This is true for hardware and software as well as services—for example, an SME producing a "high end" CD player will have to achieve the standards of performance, reliability and documentation set by Sony.

4. I am unsure whether there is today a social stigma attached to corporate failure, but the City in general and venture capitalists in particular are unforgiving about earlier failures. This is much less the case where individuals (angels) are backing a venture.

5. EASDAQ will in principle improve the ability of high-growth companies to attract investment provided:

- it keeps fees and bureaucracy in check;
- class type actions do not become prevalent from disappointed investors;
- it is well marketed internationally (as is NASDAQ).

It will greatly benefit from some early successes!

6. I personally think that this is the flaw in Foresight.

7. A large proportion of business leaders do not have a technical background and may be risk-averse to organic technological development. Ideally, such people need personal exposure to technologically driven business opportunities and should participate in active debate about such opportunities. Because of the competitive problem, such debates would have to be done within a company environment and therefore we have to rely on a Foresight aware individual creating such a debate. Members will see the circularity of this argument.

8. I am unconvinced that tax credits of themselves would encourage research and development, given that R&D expense should fit into a comprehensive business case for investment. R&D costs tend to be a small proportion of total costs and the tax credit therefore even smaller. It is unlikely that any business model is so accurate as to rest on a tax credit variable. However, a tax credit would of course be a signal that R&D is a good thing to do!

### Brief Notes on Clarification Issues

1. See organisational chart attached (Annex).

2. Within the overall staff employed by Generics, approximately 35 per cent are women. Of the scientific and engineering professional staff, 13 per cent are women which we believe to be higher than average given that this group is involved in our hardware and software development as well as in life sciences. For example, of the overall membership of the IEE, only six per cent are women.

The recruitment and retention of women in technology-based posts is consistent with our mission and supported by our culture. We have created a working environment attractive to the highest quality people. This environment attracts people from many nationalities and different backgrounds; it is attractive to the highest calibre engineers, technologists and scientists whether male or female. Particular cultural aspects which contribute to recruitment and retention of women include:

- the principles of meritocracy and equality which underpin our management structures and processes, providing a very positive and non-threatening environment without the hierarchical status symbols inherent in more traditional organisational cultures;
- time flexibility which excludes regulation of start and finish times and includes 24-hour opening of our offices and laboratories, and geographical flexibility enabled by our extensive use of e-mail in the office and at home;
- our clear commitment to helping working parents balance their commitments at work and outside of work, including availability of sabbatical leave, positive approach to family-related time-off requirements, and our early involvement in *Opportunity Links,* the pioneering Internet-based information service for parents.

We are also committed to the ongoing development of all of our staff, as demonstrated by our work to achieve the *Investors in People* national standard for training and development. This is not only a business imperative but it is inherent in our culture. Career development extends to all employees and individuals have the freedom to develop their career and cultivate their technical know-how in the direction that suits them and their particular circumstances. We have found this to be an attractive approach for all of our employees and potential employees.

3. Three examples of Generics' contribution to public sector policy:

*Proficiency Testing in the UK*

In 1989 the Community Bureau of Reference (DG XII) of the Commission of the European Communities initiated an assessment of proficiency testing schemes of member states. These proficiency schemes are programmes designed to analyse and compare the performance of standards laboratories. These laboratories provide testing for industry and government ranging from environmental monitoring, such as airborne asbestos fibre counting, to hospital clinical analyses. The proficiency schemes, as well as the participating laboratories, can be private or government sponsored.

The programme at DG XII intended to identify and evaluate the various proficiency schemes on a state-by-state basis to allow comparisons to be made and eventually community-wide standards to be set. Generics was funded by the Commission to investigate the proficiency testing schemes in the UK. This work entailed identifying and classifying the schemes in operation. Before this investigation had begun there was no central directory or listing of schemes available. Once the schemes were identified, contact persons were located and interviewed according to a standard proforma. The results of these interviews and other available information were assessed and compiled for the Commission. Generics was able to interpret and consolidate information pertaining to a wide variety of technical disciplines, a process which was facilitated by Generics' interdisciplinary approach. The resulting report set a new standard for investigations of this type for DG XII, and was widely circulated by that organisation.

*Priority Setting for the National Measurement System*

Scientific Generics has worked with the National Measurement System Policy Unit (NMSPU) of the UK's Department of Trade and Industry to set up a robust, reasonably quantitative, dynamic, priority-setting system. The NMSPU has responsibility for supporting the measurement infrastructure of UK industry as outlined in a government White Paper entitled *Measuring up to the Competition,* July 1989. Seven policy areas were identified, so that the national measurement system must: enable innovation in UK industry; improve quality in UK industry; inform the content, or enable implementation, of UK or EC regulation; inform public policy; reach a large number of users; support other, dependent, measurement work.

Historically, development programmes were proposed and managed by government laboratories. After the introduction of the client/supplier principle, and the status change of the laboratories to agencies, management responsibility was passed to the NMSPU, which thereby acquired some 15 development programmes of about 10 projects each. The NMSPU has to negotiate its spending budget, against other spending departments, within the overall DTI budget (itself subject to change), and manage the programmes within that budget. Targets have been set for a proportion of development work to be allotted by public tender.

To help manage this complex process, the system set up by Scientific Generics is based upon a detailed cost/benefit analysis, at project level, taking into account a variety of inputs including the policy guidelines, external expert judgement and advice, and industrial sector economic weightings. Generics demonstrated that, despite the complex techno-economic environment in which the NMS operates, a suitable cost/benefit indicator can be derived from three principal components:

- an assessment of benefits, known as the policy score;
- an economic importance indicator;
- an estimate of expected costs.

The methodology was devised and tested, standard forms and software prepared and, for each project, briefing papers and economic importance matrices were produced. For the future, most programmes are expected to be refinements of existing programmes. In particular, the potential exists for optimising policy weightings to maximise the cost/benefit indicators.

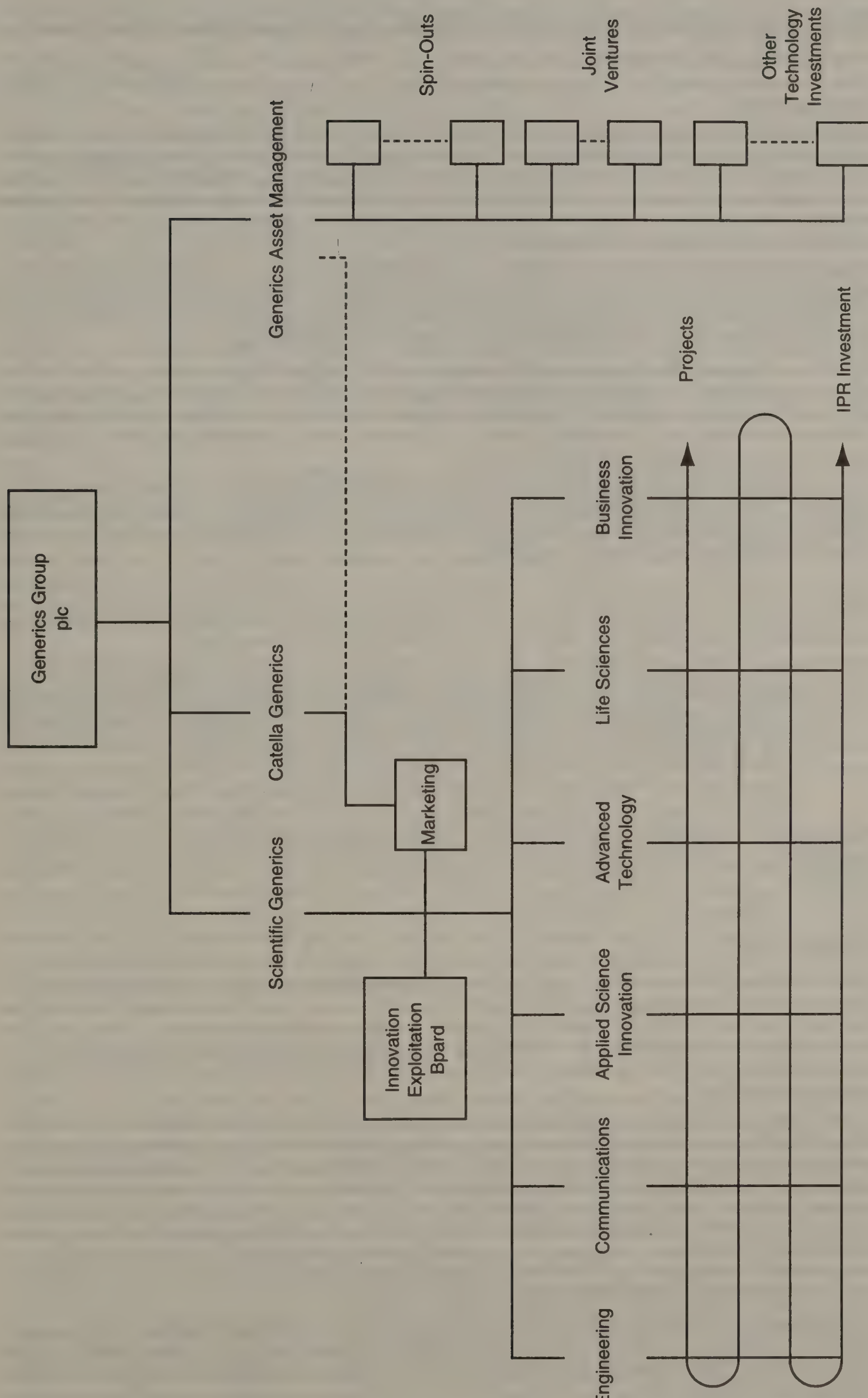
This work is now being updated and reviewed after an eight-year gap in a new project for the DTI.

*Mesopic Lights Standards*

We have also recently completed, for the DTI's National Measurement System Policy Unit, an innovative piece of research into visual performance where no standard previously existed. One objective was to provide the Standards sector with a measurement standard that is relevant to modern measurement issues so as to enable innovation in products and systems operating at low light levels. For example, taking account of an increase in human response time as light levels fall.

*3 July 1998*

## ANNEX


Generics Group plc
Generics Asset Management
Catella Generics
Scientific Generics
Spin-Outs
Joint Ventures
Other Technology Investments
Marketing
Innovation Exploitation Bpard
Projects
IPR Investment
Business Innovation
Life Sciences
Advanced Technology
Applied Science Innovation
Communications
Engineering

## APPENDIX 31

### Letter to the Clerk of the Committee from Mr Chris Hacon, Great Yarmouth Recommissioning Partnership

We are writing to you in your capacity as Committee Clerk, Science and Technology Select Committee to inform you of the innovative work being carried out by the Great Yarmouth Recommissioning Partnership (The Partnership).

The Partnership comprises representatives from the oil and gas industry, small and medium enterprise (SMEs), local government and scientists from the University of East Anglia. The fundamental aim of the Partnership is to act as a facilitator to enable innovation to develop into commercial activity. At the present time the Partnership is undertaking the task of introducing the reuse of oil and gas platforms in the southern North Sea. This process involves moving platforms from redundant fields for refitting, before moving to a new site, a technique known as recommissioning.

Along with this letter we have included a document outlining the case for recommissioning.[22] This document also demonstrates the thinking behind, and the benefits of, forming partnerships to promote innovation and subsequent commercial gain. In the final part of the document we have delineated certain means by which the Government could assist the progress of recommissioning.

The Great Yarmouth Recommissioning Partnership would be delighted to give evidence relating to either of the areas of interest covered above should the Committee consider such information appropriate to its existing or forthcoming enquiries. We would welcome your Committee's response to recommissioning and any other observations your Committee has made on the complex issues surrounding the future of the energy industry and the establishment of energy policy.

The Partnership is hosting a conference on the future of the Energy industry in Great Yarmouth on 16 April 1999. We would be delighted to extend an invitation to members of the Science and Technology Committee. Please don't hesitate to contact any of the members of the Partnership should you wish to receive further information on any aspects of our work.

### Fundamental Reasons why the Activities of the Great Yarmouth Recommissioning Partnership are of Relevance to the Work of the Science and Technology Select Committee:

— Firstly, it is common knowledge that over the next 25 years oil and gas reserves in the North Sea will become progressively less viable, and the Government will be under increasing pressure to build this factor into their energy policy. Therefore, it is important to examine the development of recommissioning and its significance in facilitating greater sustainability in the energy sector. In short, recommissioning can provide an extended life to the offshore industry.

— Secondly, the role of the partnership approach in the creation and development of innovation, and perhaps more importantly, moving innovation on to the all-important stage of commercial gain.

We have recorded the text under two headings: *Recommissioning* and *Innovation through Partnership*. Together these headings sum up the activities and objectives of the Great Yarmouth Recommissioning Partnership.

### Recommissioning

Earlier this year the Government, along with 14 other European nations, gave greater momentum to the recommissioning process by agreeing not to dispose of steel platforms at sea. This agreement was part of the Oslo-Paris Convention (OSPAR) which is designed to protect the marine environment in the North East Atlantic. Such an agreement is in line with the Government's waste hierarchy, which favours reuse ahead of recycling and disposal. Recommissioning offers a perfect fit to both these initiatives that are designed to enhance sustainability.

Last month recommissioning received a further boost with the completion of the Interconnector at Bacton in Norfolk. This interconnector will enable gas to flow to and from the UK to continental Europe, thus opening up a market five times the size of the UK's. Increasing the size of the market offers opportunities for extending the life of existing fields, and makes future exploration in the North Sea, using recommissioned platforms, an even more attractive option. The development of interconnectors in harness with recommissioning offers the Government and the Nation more sustainable energy production and the perfect foundation on which to base a long-term energy policy. Such developments buy the Government and the oil and gas companies time, as they move toward decommissioning oil and gas fields and into the era of generating more of the Nation's energy from sustainable sources.

Using present estimates of the life of oil and gas fields, the peak years for decommissioning are likely to be between 2003 and 2012, and it is during this period that recommissioning will be most attractive to the offshore industry. With close to 160 platforms in the southern North Sea alone, the potential for

[22] See below.

recommissioning is enormous. Indeed, the cost of decommissioning all the platforms in the North Sea is estimated at approximately £6 billion. Recommissioning will enable companies to reduce costs by increasing the effective life of platforms, and will provide the means for companies to spread costs over a longer period, as the life span of fields will be increased by virtue of the reduced overheads offered by the recommissioning process.

The Partnership is proposing the modification and development of Versatruss removal technology for transporting the larger of the platforms located in the southern North Sea to Great Yarmouth for recommissioning. Versatruss is based on a catamaran style "A" frame which is already being used successfully in the Gulf of Mexico, following support from BP Amoco, to move platforms many hundreds of miles. This technology has enabled around 30 per cent of the topsides of platforms in the Gulf of Mexico to be recommissioned, thus saving companies 40 per cent of costs when compared to replacement with new structures. However the Gulf of Mexico experiences very different sea states from the southern North Sea. Therefore the Partnership's Great Yarmouth based expert in this field, Versatruss Europe, intends to advance the technology to overcome the challenge of rougher sea conditions. Important alterations in the lifting technology and methodology are also required to accommodate the specific structural design of North Sea installations. To establish new lifting methods the Partnership is proposing to develop and trial the most recent lifting gear in the southern North Sea, whilst also collating and disseminating information about other innovative lifting techniques. These trials are vital in order to identify, quantify and overcome any potential risks posed by the use of significantly modified lifting technologies, in sea states far removed from the Gulf of Mexico. This approach is linked to the development of refined recommissioning processes at Great Yarmouth.

The aim of both transport and recommissioning technologies is to extend the life of platforms by refitting and reuse. An obvious every day comparison can be found in the way a motorist might refurbish and service a car before either selling on, or getting a few more years use, rather than consigning the vehicle to the scrap heap. The major difference between the two examples is that unlike scrapping a car, decommissioning an offshore platform is a very expensive exercise. The generic name for this mechanism is mature assset management: this involves the treatment of a resource, whether it is a car or gas platform, as a renewable resource rather than a waste product. This delays the cost of decommissioning and saves the costs of new construction.

Recommissioning also has a political value, as it offers the Government an opportunity to promote environmental considerations whilst enhancing the competitiveness of the British economy. This eco-efficient approach to environmental challenges is in line with the Government's commitment to the aims of the Rio Conference, which sought to encourage sustainable development. Furthermore, recommissioning will not impact negatively on construction jobs, as there are no new platforms under construction in UK yards at present. Moreover, new jobs would be generated and existing jobs secured, both offshore and onshore, in undertaking the task of transporting and refitting platforms.

Much publicity has been given over the years to the importance of North Sea oil and gas revenue in keeping the finances of Great Britain plc in a healthy state. By extending the life of oil and gas fields in the North Sea recommissioning can play an important role in enhancing government finances. Moreover, the challenge of dealing with ageing platforms is global: consequently refined technologies and methodologies developed by the Partnership in the southern North Sea could provide numerous export opportunities both for the technology and the recommissioned platforms. However, perhaps of more long-term importance is the means by which the Partnership approach can offer an imaginative and constructive cure for the British disease of failing to capitalise on home-grown inventions and innovations.

### Developing Innovation Through Partnership

The Great Yarmouth Recommissioning Partnership provides an example of the means by which the oil and gas industry and scientists can combine with other important stakeholders to produce and develop techniques and methods capable of answering pressing environmental problems. By bringing together different parties in an interdisciplinary fashion, common ground can be established and solutions produced by a pooling of expertise. This teamwork approach has enabled the development of imaginative and viable outcomes, which provide a way out of the impasse between environmental, social and commercial concerns, to emerge with a high degree of deliberation leading to greater levels of consensus.

The whole issue of consensus building is enhanced by the inclusion of representatives from local government. The local authority is an important stakeholder in the development of the recommissioning process, which will impact on the local environment and community. This approach offers the commercial partners an early insight into the views of the local community and enables ingenious solutions to evolve in advance of, and in response to, wider concerns. In the case of Great Yarmouth the impact on the tourist industry of bringing platforms on shore has been considered by the Partnership. Due to the broad cross-section of stakeholders, ideas have emerged such as the creation of a visitor's centre, to develop and disseminate information about the energy industry in an entertaining and educational manner. The basic

principle is to turn what is perceived as a problem on its head by transforming the seemingly mundane activity of refitting oil and gas platforms into a tourist attraction. This has the added value of both educating the public on energy issues and enabling public values to be identified, articulated and thus incorporated into subsequent decisions on energy futures.

Small and medium enterprises (SMEs) also play a vital role in the Partnership's approach and this is reflected by the membership of two SMEs on the Partnership. Indeed, in the region of 300 contractors in the Great Yarmouth area have been identified as potential beneficiaries of the use of recommissioning technology at the Town's port. The Partnership has an important role to play in collecting information from SMEs on recent development in their industries. This intelligence gathering enables members of the Partnership to share fresh knowledge, and efficiently disseminate the information collected. This is of great value to SMEs, who are able to tap into the partnership's networking activities to enhance their knowledge base. It also provides a mechanism for the Partnership to pick up on new ideas and best practice in the energy sector and associated industries.

As outlined earlier in this document, the principle underlying much of the Partnership's activities is mature asset management, and this concept provides the potential for numerous research and development opportunities, in the energy industry and beyond. The stakeholder partnership model, exemplified by the Great Yarmouth Recommissioning Partnership, offers the perfect platform on which to further the mature asset principle. Undoubtedly, consensus building through the Partnership approach has enhanced relevance when set against a backdrop where increasingly reuse is becoming the preferred environmental and commercial option. To this end the Partnership has discussed the creation of a Centre for Excellence in the Energy Industry, which would seek to initiate and develop innovations designed to reduce global warming by helping the Government meet emission targets. The Partnership approach offers a fresh formula for sparking innovation: by the deliberative examination and discussion of issues by a team of experts and interested parties with a clear objective in mind, in this way partnerships can promote eco-efficient solutions that have a broad base of support.

In his Pre-Budget Statement the Chancellor, Gordon Brown, said: "Our policy is pro-skill and pro-science". He added "to turn scientific invention in Britain into jobs for Britain, we need to do more to honour the spirit of invention, facilitate the exploration of invention and encourage the commercialisation of invention". His statement chimes with the aspirations of the Partnership. In summary the Great Yarmouth Recommissioning Partnership is addressing the use of new technologies and environmental challenges, whilst seeking to provide sustainable employment in the UK energy sector. In a recent debate in the House of Commons John Battle, Minister for Energy and Industry, referred to the Great Yarmouth Recommissioning Partnerships approach as the three term equation of win, win, win.

MEASURES THE GOVERNMENT SHOULD CONSIDER TO ASSIST THE RECOMMISSIONING OF OFFSHORE PLATFORMS AND THE DEVELOPMENT OF THE PARTNERSHIP APPROACH TO RESOLVING QUESTIONS IN THE ENERGY SECTOR:

- Joint funding for comprehensive trials of innovative lifting techniques in the southern North Sea such as Versatruss;
- Political support to ensure that platforms for recommissioning, which are based in the southern North Sea, come to the most appropriately located UK port, of which Great Yarmouth is a prime contender;
- Recognition of the export potential of the advanced recommissioning technology being developed in the southern North Sea;
- Recognition and financial support, where appropriate, for the evolution of the Partnership's work into the future development of innovation into environmental and commercial benefit in the energy sector;
- Funding for an environmental overview of the process of recommissioning which would clearly establish the benefits of reuse in the offshore sector;
- Recognition of the partnership approach to meeting environmental, social and commercial challenges in a sustainable way;
- The introduction of a clause in the Costed Abandonment Programme (CAP), requiring operators to demonstrate that the recommissioning option has been fully explored before a platform is sent for decommissioning; and
- Assess the potential for involvement and participation of the Partnership in the recently formed North Sea Taskforce.

*7 December 1998*

## APPENDIX 32

### Memorandum submitted by Halliburton Manufacturing and Services Ltd

1. Introduction

The Halliburton Group of companies is headquartered in Dallas, Texas, USA. It has an annual turnover of US$16 billion (1997 figure) and has 100,000 employees in approximately 160 countries worldwide.

In the UK the company employs some 6,000 people engaged in oil and gas industry services, and in providing a wide variety of non-oil related engineering and technical services. Halliburton Manufacturing and Services Ltd is the principal UK subsidiary of the company.

This Memorandum has been prepared by Ian C Phillips, a British national with 20 years experience in the UK oil and gas industry. He holds a Masters degree in Petroleum Engineering (1983, Heriot Watt University, Edinburgh) and an MBA (1994, The Open University).

Halliburton Manufacturing and Services Ltd is participating in a current applied research project to develop fibre-optic and photo-etching technologies to detect very low concentrations of oil-based pollutants in seawater. The resulting product will be commercialised by another project participant, Hook & Tucker Ltd. Halliburton is interested in taking the resulting sensor technology and packaging it for use within oil and gas wells.

Mr Phillips was the initial sponsor of the project internally, and the first Project Manager. He has since transferred to another company subsidiary and been replaced as Project Manager.

2. Responses to Specific Questions

2.1 *How did Halliburton first learn about LINK?*

The LINK scheme was brought to our attention by a researcher at our local University, and was proposed as a possible source of funds if we were prepared to offer matching financial support.

2.2 *The reasons Halliburton decided to participate*

Prime reason was an interest in the technology that was to be researched and developed. In our view the technology would be highly relevant to our business if successfully developed, but we perceived a significant risk that the proposed technical approach would fail to function in practice.

Secondary reason was that the existence of Government funding reduced our level of financial investment to a point where the decision could be taken rapidly and locally (in the UK), rather than having to be referred to others in the USA. This generally increases the probability of the research work occurring in the UK.

2.3 *How easy or otherwise did Halliburton find the initial process?*

The mechanics of the application process seemed unnecessarily complex. Specifically

- The need to produce detailed company accounts for highly specific periods seems unnecessary. I understand the need to confirm the financial viability of the entities participating, but would have thought that the most recent annual reports plus a more general statement of current financial health from the companies auditor or accountant would be sufficient. As an alternative, why not simply use a commercial assessment agency such as Dun and Bradstreet, and charge the applicants for this "health check".
- The forms make it difficult to communicate the relationships between participating organisations. Each applicant files a separate form, but these forms are not effectively drawn together to present a coherent picture. We spent an unacceptably long time explaining matters to civil servants when the issue was the poor quality of the forms we were required to complete.

2.4 *Has our involvement in LINK met Halliburton's objectives*

Our desired outcome is the development of a particular technology and associated applications that have immediate value for the other commercial participant in the project. Our commercial interest is in taking the finished product and incorporating it as part of a wider system to be installed in oil and gas wells to enhance production and reduce maintenance costs.

As the project is still in progress, the final outcome is not yet available for evaluation—although progress is satisfactory.

2.5 *The impact that LINK has had on Halliburton*

As our investment is approximately £125,000, this project is not significant in the context of our company wide US$300 million R&D spend globally (1997 figure).

The greatest impact that the LINK funds had was to enable UK based staff to justify undertaking collaborative research at a UK university. More commonly our company undertakes such work at US universities which have good connections with head office staff in Houston or Dallas.

2.6 *What barriers prevent Halliburton from gaining more from LINK*

None related to this project.

In general, our US ownership creates a perceived disadvantage in applying for UK government assistance. We had to carefully plan which legal entity to involve in this research.

I perceive that the objective of LINK funding is to

- Ensure the research is carried out in UK/EU research establishments
- Ensure that any subsequent commercialisation of the research benefits UK employment

I would therefore suggest that the onus should be on the project participants to demonstrate that this will be the case—rather than attempting to achieve this goal in some more oblique manner (eg insisting on UK domiciled participating companies).

2.7 *Our overall assessment of the scheme*

Broadly favourable.

Basic objective of encouraging practical, commercially relevant research within the UK is well met.

Participation of industrial verifiers a good innovation—protects Government interest without forcing the participants to educate a technically ill-informed civil servant in the technical minutiae.

Initial bureaucracy could do with greater clarity of aim and methodology, leading to simplification.

*26 January 1999*

## APPENDIX 33

### Memorandum submitted by the Higher Education Funding Council for England

INTRODUCTION

1. Higher Education Institutions (HEIs) receive funding for research and research training from a variety of sources, including the Research Councils (RCs), Government departments, the EC, charities, and industrial and commercial sponsors. Grant provided by the Funding Councils is usually the largest single source of funding, but—particularly in HEIs with a substantial portfolio of research activity—this generally accounts for a minority of income. In the higher education sector in Great Britain, research related grant from the Funding Councils formed 34 per cent of the research specific income received by the sector in 1995-96, the latest year for which full data are available (total funding council income = £779m, total external income = £1,532m).

2. Funds provided by the Funding Councils are fundamental to the support of research undertaken in HEIs. By supporting the provision of premises, equipment and permanent staff they contribute to the infrastructure costs which underpin the dual support arrangements. More specifically, the research component of the HEFCs' block grant has three purposes:

(a) it covers a majority of the costs of the basic research undertaken by universities, which forms the foundation for strategic and applied work, much of which is supported by other Government funds (from research councils and departments) and by charities, industrial and commercial organisations.

(b) Since the 1992 change in the dual support arrangements between RCs and universities, the HEFC block grant has contributed to the costs of permanent academic staff and premises required for RC projects; it also contributes to the infrastructure costs of other collaborative research undertaken by universities in conjunction with RCs.

(c) It contributes to the substantial fixed costs of training research students, in particular staff, premises, equipment, libraries and other essential facilities.

3. In allocating resources to institutions the Funding Councils apply a number of principles. These follow extensive consultation both within the HE sector and more widely. They are:

(a) Plurality. The Funding Councils' allocations build on the advantages which the availability of a range of funding sources brings, and seek to complement but not duplicate the aims of other funding agents.

(b) Selectivity. Funding Councils allocate funding selectively, according to the quality (determined through periodic Research Assessment Exercises) and (above a certain quality threshold) the volume of research carried out in each department in each institution.

(c) Balance. The Funding Councils seek to reinforce excellence, but also consider it important that funds should be available to encourage research potential and the development of new and interdisciplinary areas of work. Maintenance of a broad base of research and training in science and technology in the UK is essential.

(d) Competition. All HEIs are able to compete for the resources at the Funding Councils' disposal. Success, however, depends on the quality of the research undertaken and on its scale.

(e) Accountability. The Funding Councils require evidence from institutions that research activities are well managed and have clear strategic aims.

HEFCE View of on Funding for University Research Carried out in Collaboration with Industry

4. Ensuring that higher education is responsive to the needs of business and industry and contributes to wealth creation and national competitiveness is a key part of the Council's mission. In pursuit of this we promote partnerships between HEIs and industry, the transfer of knowledge and the encouragement of employment skills.

5. Work carried out in collaboration with industry has always been submissable to the Research Assessment Exercise and submissions can include research outputs other than publications, such new materials, devices, products and processes. We believe there is no inherent bias within the RAE to the appropriate assessment of research carried out in collaboration with industry and that where it is of high quality this is rewarded by our selective funding approach.

6. However, we recognise that some have felt the RAE panels lacked sufficient expertise to appropriately assess work of industrial relevance. We have therefore implemented a number of changes for the 2001 RAE to provide reassurance that this type of work is properly assessed including increasing the number of research users on the panels, developing explicit criteria for the assessment of industrially relevant work where necessary and ensuring that the assessment process itself does not discriminate against industrially relevant work. In order to ensure that we get this right we have established a joint task group with the CBI.

7. The HEFCE has encouraged particular types of HEI-Industry interaction through both the Generic Research (GR) funding initiative—which provides incentives for industrial collaboration where intellectual property rights are shared—and the Joint Research Equipment Initiative—which facilitates collaborative research through joint funding of equipment. In addition the Council's Continuing Vocational Education (CVE) has provided £60 million over four years for HEIs to develop CVE courses.

8. That extensive links between higher education and business already exist is shown in reports commissioned by the DTI from Tartan Technology in 1996 and by the HEFCE from PREST in 1998. Although there is much evidence of good practice, its distribution is somewhat patchy.

9. It is in part to support the spread of this good practice that we have launched our most recent initiative, to which you specifically refer, the Higher Education Reach Out to Business and Community fund. This targeted funding for institutions, provided over a 4 year period (but renewable), will provide an incentive to build a sustainable and broadly based capability to respond to the needs of industry and commerce. Thus, we expect this new fund to change institutional and academic cultures in order to attach greater value to activities which are relevant to the needs of employers and industry and thereby enable them to put into practice their strategic aims in this area. In building capability it should be noted that the Reach Out Fund will not support any particular sector or discipline. Notwithstanding this, those areas where there is most actual, or desire for, interaction would be expected to benefit most from the enhanced capability of HEIs to respond to industrial needs and this might be expected to include the physical and engineering sciences.

10. We will provide £10 million in 1999-2000, and £20 million each year thereafter, with the expectation that this will become a permanent new funding stream with allocations of grant made for four years in the first instance. The DTI has provided £6 million additional funds towards the programme. HEROIC will be bid based, although we will not define closely what is funded, institutions will set their targets and the outcomes will be monitored and evaluated.

11. Examples of activities that might be funded by the HEROIC fund include: developing IPR expertise; developing a centre of expertise in business links; training and development for staff, including staff exchanges; mechanisms and materials to promote and explain HE products, processes and services; one-stop shops to enable business to access advice from HEIs more readily; business incubator units; or improving CVE programmes to meet local and regional needs.

12. The emphasis on building general capability, the primary aim of the Business and Community Fund will distinguish our approach from that of many other specific funding initiatives. There is a parallel here with

the dual support system for research where the Funding Councils provide academic staff, and basic infrastructure (principally buildings, major equipment and libraries) to enable institutions to respond to mission driven programme and project funding provided by research councils, charities and industry. Funding provided to HEIs under the proposed programme would lead to improvement not only in their delivery of knowledge and services to industry but also in their capacity to respond to related initiatives mounted by other agencies.

13. Although one of the benefits of the Business and Community Fund would be more widespread, systematic and rapid transfer to businesses of new ideas, products and processes generated within HEIs, we recognise that working with industry is not simply about transfer of ideas but just as important is improved access to and use by businesses of graduates and diplomates, products, resources and services produced in HEIs; improved relationships between HEIs and businesses at the personal level, using staff transfers, postgraduate student placements and other mechanisms to encourage mutual understanding and activity, especially at the level where the knowledge transfer takes place; and enhanced institutional capacity to respond in a concerted and effective manner to other initiatives promoting employability, enterprise and self-employment skills, particularly where knowledge transfer is concerned. We are framing the new fund so that it will facilitate these activities.

14. In recognising that much transfer takes place by the flow of people, that institutions have diverse missions and the need to embed changes in institutions, we propose two additional measures to make up a three-pronged approach to promote knowledge transfer and employment skills:

(a) To encourage measures to promote employability through our learning and teaching strategy.

(b) To encourage and provide improved information and dissemination through the work of our Business and Community Committee, which has made employment issues its top priority, and is seeking ways in which the two way flow of information between the HE sector and industry can be improved.

### Industrial Application of Government Funded Research, Intellectual Property Rights and the Provisions of Finance to Support Enterprises Involved in the Application of Research and Innovation

15. The GR funding scheme is evidence of the HEFCE's wish to facilitate the commercialisation of publicly funded research and further support has recently been provided with the launch of the Business and Community Fund; the HEFCE welcomed the launch of the University Challenge fund which it sees as complementary to the capability building fund which it is financing.

16. GR and Business and Community funding both underpin the principle that HEIs should have access to sufficient expertise and advice to ensure they benefit appropriately from the commercialisation of their research by maintaining an interest when their IPR is exploited by others.

### The Respective Roles of Government Laboratories and Independent Research and Technology Organisations

17. We see the role of Government funded science as providing support for curiosity led research that is publicly available for the general good. The importance of this type of funding is that it ensures the vitality of the research base in the short, medium and long-term.

### The Operation of Government Schemes Designed to Promote Collaboration in, and Industrial Application of, Research and the Role of Foresight in Fostering Networks and Identifying Priorities

18. We welcome the diversity of schemes available to meet the particular needs of different organisations, people and sectors and for different types of knowledge production. It is of course important that these are synergistic and do not duplicate one another, but we believe that this is the case with current policies.

*28 January 1999*

## APPENDIX 34

### Letter to the Clerk of the Committee from Professor David Horsley

Thank you for your letter of 15 July and the invitation to submit my views on the Newcastle University Engineering Design Centre and the Regional Centre for Innovation in Engineering Design to the Science and Technology Committee.

1. The Engineering Design Centre

British Nuclear Fuels has, for some years, been a member of the Newcastle University Engineering Design Centre which specialises in research into the design of "made to order" products and plants. Because of the nature of BNFL's business, every process plant that it requires to carry out its business and every new facility which is needed to recover and stabilise the historical wastes is a "made to order" plant.

A major challenge in the design of made to order plants is that there is limited accumulated experience from past plants and this makes it difficult for the design team who are nonetheless expected to achieve the optimum balance between often conflicting objectives such as capital cost, availability, lifetime cost, process performance, safety and environmental impact etc. From its inception, the Engineering Design Centre recognised this challenge and the increasing complexity of design decision making. The development of tools and techniques to facilitate design decision making when faced with a large number of apparently conflicting criteria and to guide designers to an optimum solution has been a key part of the EDC's research programme.

Much design, even since the adoption of CAD techniques remains, of necessity, sequential, ie the work of one engineering discipline tends to follow sequentially after the work of another is completed. Many organisations such as BNFL have recognised the potential benefits which would be gained from the development of an integrated design capability which would enable the consequences of any design decision to be instantly seen and consequent problems avoided, thereby reducing the time, rework, cost, and risk in the design process.

A major research initiative within the EDC has been and remains the development of the ability to integrate all aspects of design. This programme allied to the multiple criteria decision making tools and the specific design modules such as spatial engineering, design for upgradability and design to minimise environmental impact and cost which are being developed in the EDC makes its work, in my opinion, world class. The list of major UK companies, including British Aerospace, British Gas, Amerada Hess, Shell Offshore, Kvaerner Water, AMEC, GEC Marine, Vosper Thorneycroft British Steel and Seimens Power who are members of the EDC is testimony to the high regard in which the work of the EDC is held.

Whilst companies such as BNFL will continue to invest in appropriate state of the art design software and hardware, commercial and programme pressures make it almost impossible for them to initiate and sustain the more visionary fundamental research and development that the EDC has specialised in and it is this complement to industry that makes the EDC so valuable.

2. The Regional Centre for Innovation in Engineering Design

The success of the Newcastle Engineering Design Centre led to the formation of the Regional Centre which as its name implies is regionally rather than nationally focused and has given very valuable support to a large number of small and medium sized companies in the North-East of England.

Small companies, particularly those in the process of organic growth, usually lack the technical and financial resources to make quantum technological steps in design and manufacturing without assistance. They certainly cannot afford to make the wrong decision when investing in high technology for the future.

The Newcastle RCID has been very successful in assisting small local companies in these areas and could well be a role model for other regions. There are some aspects of its operation, philosophy and history which should be taken into account when considering setting up other Regional Centres:

- The operational model adopted within the RCID is based upon the experience gained in operating the highly successful EDC over a 10 year period, ie, inter alia a very strong focus on industry's needs—Customer Focus.
- One primary reason for the success of the RCID is the fact that it is seen by the Region's decision makers as an important part of the Region's Innovation and Technology Strategy.
- A key factor in the success of the RCID is the commitment of a group of leading industrialists in the Region. These individuals were selected with great care during the formative stages which led to the RCID being set up.
- By involving all of the Universities in the Region in the collaborative venture, Industry sees the RCID as truly Regional and not simply a Newcastle University initiative.
- Whilst much of the work of the RCID is near market, as it must be if it is to benefit SME companies on an acceptable timescale, it does undertake a certain amount of more fundamental research work. These projects are often based upon output from the EDC programmes. This is, in effect, a classic example of the Supply Chain model.
- The support of the Region's Agencies is a very significant factor in the success of the RCID. For example the RCID has two visiting professors sponsored by the Tyneside TEC and the Tyne and Wear Development Corporation, their focus being the activities of SME companies.
- The involvement of the TECs and Business Link is important. The RCID has used these networks to encourage SME companies to participate and the Northumberland Business Link Counsellor is a member of the RCID staff and is based in the Centre.

— The RCID plays an important role by collaborating with local Agencies when they are negotiating with potential inward investors who see the research and development support as very valuable.

— The RCID is a focal point in the region for a number of national initiatives. For example the Regional foresight programme was, until recently, managed from the Centre. This in turn facilitated the engagement of the SME community with long term strategic research and development. Partnerships were formed between the large companies which fund the EDC and the Region's SME companies.

— The RCID also takes a very great interest in the development of people, believing deeply that technological developments and the associated change cannot be achieved without simultaneously addressing the development of personnel. The RCID holds a National Training Award.

I hope that these facts and comments will be of interest and of use to the Science and Technology Committee in their inquiry into Engineering and Physical Sciences based Innovation.

*July 1998*

**Further letter to the Clerk of the Committee from Professor David Horsley**

Thank you for your letter of 16 December. I have reviewed my previous submission to the Science and Technology Committee which gave details of the Newcastle University Engineering Design Centre and Regional Centre for Innovation in Manufacture.

I have very little to add to what I said previously. I would like to stress that in my opinion the implementation of innovation is often inhibited by the perception that the risks associated with the new and untried are unacceptable or inadequately quantified.

I accept that we need to become less risk averse and probably more technologically literate. I believe that we also need design tools such as those being developed in the Newcastle EDC which allow both the benefits and risks of new innovations to be more accurately modelled, enabling investment proposals to be better evaluated. I am not sure that we lack innovative ideas but we do lack the tools to translate the implications of these ideas into business cases that will win financial backing. I believe that engineers and technologists must learn to translate their visions into language that the business and financial community will understand.

*22 December 1998*

## APPENDIX 35

### Memorandum submitted by IBM

1. Introduction

1.1 Technology and product innovation are essential to business growth and performance in the highly competitive IT and IT services industries worldwide. In support of this, IBM invests about $5 billion in research and development relating to products and services each year. It is essential that this effort is productively focused and that the business earns an appropriate return. IBM has therefore developed an approach which relies heavily on intellectual property management to ensure that the company extracts appropriate benefits from its research and development activities.

1.2 For interest, IBM's main research development activities in the UK are at Hursley near Winchester, where hundreds of software experts push forward the development of JAVA and related software issues relevant to the Internet and electronic business.

2. Summary

2.1 IBM's evidence focuses on two of the points raised by the Committee:

— intellectual property rights and patenting

— the role of the Foresight Programme in fostering networks and identifying priorities.

2.2 IBM believes that protection of intellectual property is essential to private sector innovation. From its extensive use of patenting to protect intellectual assets, IBM has concluded that the key elements of a company's successful patent management regime are:

— open patent licensing

— making well-informed decisions about where to seek patent protection and for how long to maintain it

— identifying areas of technology-based opportunity and threat from monitoring the patent portfolios of competitors, and seeking to take appropriate action in those areas.

2.3 Although IBM has not been closely involved in the Foresight Programme, we believe that there is value from its activities in developing University/Industry relationships, particularly for smaller firms. We believe that there are two areas where it could make a further significant contribution:

- enabling cost-neutral secondment of academic researchers into companies such as IBM, that would be of great value to both parties
- identifying regulatory or social inhibitors to the commercial exploitation of inventions.

## 3. IBM's Intellectual Property Assets and Patent Leadership

3.1 Companies need to see a commercial reward from their investment in innovation, and intellectual property rights form the backbone of the process that ensures appropriate commercial returns. By way of example, IBM's intellectual property assets include:

- about 30,000 patents worldwide, with a significant number of pending applications
- over 8,500 trademarks worldwide
- a vast portfolio of copy-righted software, manuals and other product-oriented materials and business tools.

3.2 IBM has set itself the goal of patent leadership as an element within our programme for technology leadership. For five years continuously since 1993, IBM has acquired more US patents than any other company, and more in Japan than any other non-Japanese company. It has a significant number of patents in Europe.

3.3 The company has an aggressive patent strategy in Israel, India and countries in South East Asia where IT development and manufacturing is growing.

3.4 IBM's patents are licensed to about 1,500 companies worldwide, earning a substantial revenue stream.

## 4. The Benefits of Open Patent Licensing

4.1 IBM is committed to open patenting and the use of licensing as the best method of ensuring that innovation finds its way as fast as possible into commercial products. The company has found many benefits from open patenting, including:

- economical alternative litigation—IBM can develop products without an inordinate concern that an announced product will face an infringement challenge that could delay or otherwise harm the product's success
- serves to level the playing field between competitors who do invest in R&D and those who do not
- can deliver a return on R&D investment of around 20 per cent
- delivers new products to market faster
- facilitates the development of open systems capable of interoperability, a key customer requirement
- encourages the faster evolution of new markets
- accelerates the creation of intellectual property
- encourages the development of important business relationships

4.2 In the IT industry, there is an increasing trend towards licensing patents.

## 5. Focusing Patent Activity on Technology-based Opportunities and Threats

5.1 In a competitive environment, of course, excellent patent and intellectual property management addresses only part of the problem. There also remains a strong need for a company to direct R&D and patenting activity to increase competitive advantage. IBM has introduced a business process to identify the most significant technology-based opportunities and threats, which involves tracking competitor patent portfolios.

5.2 Once a particular area of opportunity or threat is identified, IBM focuses activity on that area. Indeed sometimes incentives are offered to R&D staff for inventions in the target areas. These are in addition to the awards that IBM inventors normally receive for the patent assets that they help to create. One recent incentive programme attracted 400 inventions relating to the Internet and network computing.

## 6. Seeking Protection in the Right Geographical Areas

6.1 As important as having the "right" inventions to patent, is the business of deciding where it will be cost effective to seek protection. IBM has developed analytical models and tools which assess which countries would be the optimal places to make patent applications. The models are sensitive to variables which can change quite rapidly over time and so the process is highly adaptable. Similar considerations apply to the

decision whether to maintain each patent. Because fees are high in some countries, there is a careful trade-off to be made between the value of the patent and the cost of extending its life.

6.2 Patent costs are high in Europe relative to the US given the need for multiple national patents and translations. This clearly presents a disincentive to the owners of intellectual property considering where best to seek protection.

### 7. Future Developments in Patent Management

7.1 Future developments that IBM expects in the area of intellectual property include:

- licensing other intellectual property eg trade marks, and technology
- hybrid licensing—licences that provide a bundle of intellectual property rights
- assigning patents to others where the technology is not core to IBM's business.

7.2 IBM supports the discussions taking place through the Transatlantic Business Dialogue on the harmonisation across countries of patent formalities, practice and legal requirements. Particular areas of interest are the cost of patent protection, clarity over the date of first filing and the protection available for software-related inventions.

### 8. The Role of the Foresight Programme in Fostering Networks and Identifying Priorities

8.1 IBM has had little involvement with the Foresight Programme, for two main reasons:

- its UK orientation sits uncomfortably with the company's own global R&D strategy
- small firms are better placed to take advantage of the partial government funding than large companies and this is entirely appropriate.

8.2 We have, however, had indirect involvement through other projects, such as the charitable Tomorrow Project and other organisations, such as CEST (Centre for the Exploitation of Science and Technology). One area of work that we believe the Foresight Programme could most helpfully explore is in developing an understanding of how to encourage commercial exploitation of inventions that have already been made.

8.3 As an example from our own industry, we believe that high telecommunications costs in the UK are holding back the growth of electronic business and the commercial exploitation of relevant inventions.

8.4 We do believe that bringing together adademia and industry is a valuable activity and the Foresight Programme has developed those networks of contacts well. If it were able to push the process further and to provide cost-neutral secondment of academic researchers into companies such as IBM, that would be of great value to both sectors.

*9 March 1998*

## APPENDIX 36

### Memorandum submitted by Imperial College Management School

1. We have limited direct experience of the respective roles of Government-funded research, Foresight Programme or Research Councils in the development of new products and processes, but base our response on our own research in this area [1,2], and understanding of others research.

2. The optimal technology acquisition strategy in any specific case will depend on the maturity of the technology, the firm's technological position relative to competitors and the strategic significance of the technology. Some form of collaboration is normally necessary where the technology is novel, complex or scarce. Conversely, where the technology is mature, simple or widely available, market transactions such as sub-contracting or licensing are more appropriate.

3. The acquisition of external technology should be used to complement internal research and development, rather than being a substitute for it. In fact, a strategy of technology acquisition is associated with diversification into increasingly complex technologies.

4. There is also a growing realisation that exposure to external sources of technology can bring about other important organizational benefits, such as providing an element of "peer review" for the internal R&D function, reducing the "Not-Invented-Here" syndrome, and challenging in-house researchers with new ideas and different perspectives.

5. No single form of collaboration is optimal in any generic sense. In practice technological and market characteristics will constrain options, and company culture and strategic considerations will determine what is possible and what is desirable.

6. Our study of how 23 UK and 15 Japanese firms acquired technology identified the conditions under which each particular method is favoured. In terms of the frequency of projects, universities were found to

be the most common external source of technology, followed by alliances, and then licensing. However, the size and structure of the sample do not allow inferences to be made about the population of UK-based firms. We review each method in turn.

### Universities

7. In the UK universities are a widely used external source of technology. These relationships range from support for PhD candidates, extra mural research awards for post-doctoral staff to carry out research in a specified area, to more formal contract research and collaborative schemes such as the LINK scheme jointly funded by the DTI and a number of companies to conduct pre-competitive research in a specified area. Firms use university research for a number of reasons: to access specialist technical support; to extend in-house research; and to provide a window on emerging technologies.

8. Extensions to existing in-house research typically involve using universities to conduct either fundamental research, aimed at gaining a better understanding of an underlying area of science, or more speculative extensions to existing in-house programmes which cannot be justified internally because of their high risk, or because of limited in-house resources. University-funded research can also be used as windows on emerging or rapidly advancing fields of science and technology. Companies view access to such information as being critical in making good decisions about if or when to internalise a new technology.

### Alliances and Joint Ventures

9. Industry structure and technological and market characteristics result in different opportunities for joint ventures across sectors, but other factors determine the strategy of specific firms within a given sector. At the industry level, high levels of R&D intensity are associated with high levels of technologically oriented joint ventures, probably as a result of increasing technological rivalry. This suggests that technologically oriented joint ventures are perceived to be a viable strategy in industries characterised by high barriers to entry, rapid market growth and large expenditures on R&D. However, within a specific sector, joint venture activity is not associated with differences in capital expenditure or R&D intensity.

10. A study of joint ventures in the US found that technologically oriented alliances tend to increase with the size of firm, capital expenditure and R&D intensity [3]. Similarly, the number of marketing and distribution oriented joint ventures increase with firm size and capital expenditure, but are not affected by R&D intensity. At the level of the firm, different factors are more important. For example, there are significant differences in the motives of small and large firms. In general, large firms use joint ventures to acquire technology, while smaller firms place greater emphasis on the acquisition of market knowledge and financial support.

11. Joint venture activity is high in the chemical, mechanical and electrical machinery sectors, as firms seek to acquire external technological know-how in order to reduce the inherent technological uncertainty in those sectors. In contrast, joint ventures are much less common in consumer goods industries, where market position is the result of product differentiation, distribution and support. Surveys of alliances in so-called high-technology sectors such as software and automation appear to confirm that access to technology is the most common motive. Market access appears to be a more common motive for collaboration in the computer, microelectronics, consumer electronics and telecommunications sectors.

12. Collaboration between firms in different industries appear to raise much less concern about proprietory positions. In most cases, they are viewed as an attractive means of leveraging in-house skills by working with organizations possessing complementary technical capabilities. Intra-industry collaborations are more important in non-competitive areas, such as in the areas of health, safety, and the environment, and in setting new standards or influencing legislation.

13. Overall, the number of alliances has increased over time, and networks of collaboration appear to have become more stable, being based around a number of nodal firms in different sectors. The nodal firms are relatively stable, but their partners change over time. Contrary to the claims of globalisation, the number of domestic alliances has increased faster than international alliances. The primary motive for collaborating with domestic firms is access to technology, but market access is more important in the case of cross-border alliances.

14. Collaboration is an inherently risky activity, and less that half achieve their goals. A study of almost 900 joint ventures found that only 45 per cent were mutually agreed to have been successful by all partners [4]. Reasons for failure include strategic divergence, procedural problems and cultural mismatch. It is difficult to assess the success of a collaborative venture, and in particular termination of a partnership does not necessarily indicate failure if the objectives have been met. For example, around half of all alliances are terminated within seven years, but in some cases this is because the partners have subsequently merged. It is common for a collaborative arrangement to evolve over time, and objectives may change. For example, a licensing agreement may evolve into a joint venture. Any measure of success must be multi-dimensional and dynamic in order to capture the different objectives as they evolve over time.

15. Factors which contribute to the success of an alliance include:

— the alliance is perceived as important by all partners;
— a collaboration "champion" exists;
— a substantial degree of trust between partners exists;
— clear project planning and defined task milestones are established;
— frequent communication between partners, in particular between marketing and technical staff;
— the collaborating parties contribute as expected;
— benefits are perceived to be equally distributed.

LICENSING

16. In theory, licensing-in a technology has a number of advantages over internal development, in particular lower development costs, less technological and market risk, and faster product development and market entry. Potential drawbacks to licensing-in include restrictive clauses imposed by the licensor, loss of control of operational issues such as pricing, production volume and product quality, and the potential transaction costs of search, negotiation and adaptation.

17. In practice, the relative costs and benefits of licensing-in will depend on the nature of the technologies and markets and strategy and capability of the firm. A survey of more than two hundred firms in the chemical, engineering and pharmaceutical industries found that the most important reasons for licensing were related to the speed of access, rather than cost [5]. Factors such as quickly acquiring knowledge required for product development, keeping pace with competitors and increasing sales were found to be most important, and factors such as the cost of development least important. Difference in emphasis exist across sectors, for example, pharmaceutical firms experience higher search costs than engineering firms, and engineering firms place greater emphasis on the potential for reducing the cost and improving the speed of market entry.

18. The most significant problems associated with licensing-in are entry costs such as the choice of suitable technology and licensor, and the loss of control of decision-making. In some cases, however, there is a reluctance to license-in technology which may adversely affect the differentiation of end products, if customers became aware of the fact. Many firms express concerns regarding the constraints imposed by international licensing agreements, specifically the common requirement to "grant-back" any improvements made to the technology. For these reasons an increasing number of firms are careful to license only components of any process or product in order to allow scope for subsequent improvement and differentiation. However, this approach to licensing is only viable where the technology can be easily "unbundled".

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*24 April 1998*

## APPENDIX 37

### Memorandum submitted by the Institute of Inventors

INTRODUCTION

The Institute of Inventors represents over 1,060 enrolled British Inventors, founded 1964, a voluntary, non-profit organisation, run by Qualified Design Engineer Professional Inventors; aims include championing Inventors and Inventions that improve the quality of life now, and to serve as a Public Watchdog to address issues on Innovation—See Appendix A and P[23].

[23] *Not printed.*

SUMMARY

A. British Inventors are outraged at the continued zero support for Inventors by successive British Governments whilst;

B. £Billions of our taxpayers' money is being bilked with the blessings of the DTI, the Office of Science & Technology, and Ministries of Transport, Environment, and Defence, through legalised scams like—

IMI, Foresight, LINK, SMART, SPUR, EPSRC, etc on worthless humbug scientific projects of no value to society/industry, under the facade of Science, Technology and Innovation.

C. We sincerely hope to alert the Committee to focus on our memorandum to:

(i) probe these scams by accepting our offer of providing Conscientious Qualified Engineers to unravel and expose the scams.

(ii) suggest remedies for terminating public funding of all scam agencies (Government, Academic and Private) operating and benefitting from the scams.

(iii) suggest use of one per cent of money saved from scams to back British inventors with breakthrough Commercially Viable Inventions to improve the quality of life now, Inventions Evaluated and Selected by Institute of Inventor Professional Engineers.

IoI REPORT TO THE ENGINEERING AND PHYSICAL SCIENCES BASED INNOVATION INQUIRY:

1. *Lack of Support for British Inventors and British Inventions:*

British Inventors have the time honoured reputation for breakthrough Inventions that have enhanced the World, like—

George Stevenson's Railway Trains,

Alexander Fleming's Pencillin, and

Frank Whittle's Turbo-Jet Plane.

Yet, successive British Governments are notorious for giving Inventors the brush-off. Had Frank Whittle's Jet Plane been backed in 1930, Word War II could have been won in a few months saving the 11 million lives lost. Today there are still Frank Whittles around in Britain with Breakthrough Inventions like—

low cost Pollution-Free Vehicle IC Engines, that can reduce Global Warming Green House Gases by 40 per cent and Safe Supersonic VTOL Passenger Aircraft, yet they receive no support and continue to be ignored by Government and all Parliamentary Parties.

2. *Private Inventors invented all major breakthrough Inventions:*

History shows that all major breakthrough inventions come from Private Inventors—

Cotton Spinning Machine invented by an English Wig maker—Richard Arkwright,

Telephone invented by a Scottish Teacher—Alexander Graham Bell,

Power Loom invented by an English clergyman—Rev Edmund Cartwright,

Water Closet (WC)—invented by an English cabinet maker—Joseph Bramah,

Bagless Vacuum Cleaner—invented by a British Art Designer—James Dyson.

The list is endless.

3. *Academia have a poor record for Innovation*

Database Records over 25 years show—

Universities filed less than 1 per cent of all patented inventions.

PhD's filed less than one in 60,000 patents.

Academia is five years behind Industry in New Technology.

4. The same records show Private Inventors filed 99 per cent of all Patented Inventions.

5. *Cashing-in by Academia/OST:*

Yet amazingly, every time there is a public outcry on "the lack of support for British Inventors", and "Valuable British Inventions going abroad", Academia and the Office of Science & Technology jump on the bandwagon and manage to procure large Government grants under the facade of Innovation, for valueless claptrap projects.

6. *Evidence of Scams*

The Committee has abundant evidence of these scams by way of access to the glossy Newsletters and Publications describing EPSRC, IMI, Foresight, LINK, OST, DTI, SMART and SPUR projects. Each report is camouflaged by bombastic jargon to give the impression that the Projects have Scientific/Technical Value, when in reality they are humbug.

7. Institute Engineers were able to reveal the camouflage of the scams on virtually every EPSRC, IMI, Foresight, LINK, OST, SMART & SPUR Publication available.

8. Most of these Government blessed legalised scams have gone on for years because existing rules favour scams and disqualify genuine viable projects of benefit to Society. Furthermore, the scams are monitored by "Privatised Contractors" whose "gift" (jurisdiction) "excludes exposing humbug" (for fear of losing their monitoring contract).

HOW THE SCAMS WORK

9. *Present Government Scam Supporting Rules* (that need changing) provide that:

Rule 1 Disqualification: If a project has immediate benefit to society—improving environment, creating jobs and wealth, it is disqualified on the grounds:

"Too near Market Place", or

"Not Pre-Competitive enough".

Rule 2 Qualification: If on the other hand a project is abstract, has no benefit to society, does not create jobs or wealth, and is so pre-competitive that it is unlikely to be used at all, (or not before 25 years), it qualifies for £millions of tax payers money.

10. *Scam Legalising Panel*

Most of the scams are orchestrated and legalised by a Panel chosen by the Office of Science and Technology who pre-select all the Collaborating Scam Beneficiaries in advance, including the Scam Managers, Scam Co-ordinators, and Scam Monitoring Officers. The Panel also set and legalise by approval Scam Targets and Scam Milestones for each Project.

11. *Scam Managers and Co-ordinators*

Every Scheme or Scam is run by a Scam Manager and Scam Co-ordinator, who are called a Project Manager and Project Co-ordinator, recruited by EPSRC or OST, often by quiet tender from pre-selected "Privatised Contractors".

12. *PhD in Flannelling*

The Scam Managers and Scam Co-ordinators usually have a PhD in a discipline alien to the project they are managing, eg a PhD in sub atomic particles may manage a Mechanical Engineering Project, or a Bio Chemist may co-ordinate an Aerospace Project. Having a PhD in a discipline alien to the project does not matter; all PhD's have expertise in "wool pulling" which makes them suitable for preparing camouflaged documents.

13. *Typical Scam Camouflage Words*

Put this key word "Computer Modelling" in front of a project title and one can legally get away with £millions for doing nothing:

£2.5 million for "Computer Modelling of turbine Blades".

No turbine blade will be produced or even drawn.

The best computers cost under £30,000—so how come £2.5 million?

The Co-ordinator "doesn't know! Ask the Professor?" The Professor won't talk.

£22 million for a "high speed machinery" project.

A misnomer as "high speed" was supposed to mean "high performance".

The only significant beneficiary supplies "cigarette making machinery".

The list is endless.

14. *Sham Invitation for Proposals*

There follows a sham pretence of inviting proposals to make it appear legitimate. Should any unsuspecting outsider contact a Scam Co-ordinator or Scam Manager to enquire about making a proposal, they are given numerous excuses why their proposal will not qualify. "Too near market place"—is the most common deterrent. In this way the scams are kept within the confines of the pre-selected legalised Scam Collaborators and Beneficiaries, who legally stand to make fortunes for "playing ball".

15. *Privatised Scam Monitoring*

Under the pretence of protecting the public purse, the scams are monitored by legalised Scam Monitoring Officers recruited by EPSRC or OST, usually by quiet tender from pre-selected "Privatised Contractors" whose "gift" (jurisdiction) only permit checks that scams meet "Scam Targets" and "Scam Milestones" set by the Scam legalising Panel. So obviously "declaring the project a worthless scam" would self destruct their monitoring contract.

16. *Scam Culture*

Since the advent of "Privatisation" a whole new scam culture has emerged in Britain. The cult of beneficiaries who concoct, pre-select collaborators, set targets/milestones, operate and monitor the scam projects are experts at "pulling the wool" and legally bilking the system at the tax payers' expense. It will require the efforts of Conscientious Qualified Experienced Professional Engineers (not Accountants) which the Institute can provide to assist the Committee to simplify, unravel, probe and expose the scams.

17. *Oodles of Scam Projects*

If the Committee are interested the Institute can provide, at a personal interview, evidence of dozens of scams orchestrated by the Office of Science & Technology, DTI, Ministries of Transport, Environment and Defence.

18. All Foresight Link Projects examined by Institute Engineers turned out to be scams.

19. As for SMART, no SMART project has earned amounts equal to their SMART award. One SMART award selection for 1st and 2nd stage was for a:

> "tamper proof baby food container" which was not tamper proof.

20. The DTI cannot cite a single SMART award Project that the British Patent Office could class as Innovative ie qualify for a Patent. A typical 1st and 2nd stage SMART award was for:

> Software that was "less innovative than a new mail order catalogue"—in fact it was a "touch screen mail order catalogue", not only known technology, but part of this company's 13 year old regular IT consultancy service being offered to clients.

21. *Defence Scams*

Since PFI, PPP, etc—MOD "Privatisation", MOD legalised scams involve such gigantic sums that the great train robbers are relegated to petty thieves. Typical legalised scams are:

> £45 million for Camp Infrastructure, £65 million for Field Electrical Generator Sets,
>
> £77 million for Tornado Simulator, £165 million for Attack Helicopter Simulators,
>
> £190 million Future Wheeled Recovery Vehicle, £300 million for Future Cargo Vehicles,
>
> £350 million for Airfield Support Vehicles, £750 million + for Satellite Services, and
>
> £40 billion for Eurofighter—a 1980's vintage—CTOL Aircraft—vulnerable to runway bomb damage, radar/heat seeking missiles, combat radius—400 miles (slightly more than a family car), Official Delivery—June 2002, by which time it is certain to be obsolete.

22. There are superior less expensive options; £20 million Manx Supersonic VTOL Stealth, three Sat cold jet engines, immune to radar and heat seeking missiles, combat radius—12,000 miles, delivery Dec 1999—twenty Manx can win a Falkland's War in three days—see Appendix M[24]. MOD decision on Manx—"no clear military application can be identified".

23. Is Parliamentary Complacency indicated by only 16 MPs attending the £22.2 billion RAF Budget Commons debate? Was it vested interests that shouted down a Labour backbencher (son of an RAF W W II Wellington Bomber Crewman) for daring to mention the folly of Eurofighter? One MP intervened "the Wogs have Migs, so we must have Eurofighter".

[24] *Not printed.*

24. *Engineers to simplify, probe and expose*

On behalf of the Committee the Institute of Inventors can provide Conscientious Experienced Qualified Professional Engineers to offer simplified explanations to the Committee and assist them to probe and expose the scams using the projects' own glossy literature and reports to unravel the purposeless, "concatenation of the scams pompous pseudo scientific verbosity". If interested, we welcome a telephone call for a preliminary discussion from a Committee Member to discuss positive ways forward.

25. *Our recommendations are that the Committee should*

(a) Accept our offer of providing conscientious Qualified Technical Engineers to simplify, reveal, probe and expose the scams.

(b) Suggest that the Government terminate funding of all agencies (Government, Academic, Industry and Privatised Contractors) operating, benefiting and monitoring the scams.

(c) Suggest that Government use one per cent of the savings from abolishing the scams to back British Inventors (of the calibre of Frank Whittle) with Breakthrough Commercially Viable Inventions that create, jobs, wealth, improve the environment and quality of life *now*; Inventions evaluated and selected by Institute of Inventors Professional Engineers; Royalties earned from backed inventions used to repay grants with bonuses to help other Inventors many times over.

(d) Suggest using the remaining Public money saved by abolishing the scams to improve the plight of Nurses, Doctors, hospital waiting lists, and benefits to all deserving cases currently being told there are insufficient funds.

26. The Institute of Inventors looks to a positive response from the Science & Technology Committee conducting the Engineering and Physical Sciences Based Innovation Inquiry.

*15 May 1998*

## APPENDIX 38

**Letter to the Clerk of the Committee from Dr Alun Jones, Chief Executive, the Institute of Physics**

The Institute is pleased to comment on the specific points raised by the committee:

### The Industrial Application of Government-funded Research

Large industrial companies rarely exploit directly Government-funded research discoveries or the related intellectual property that is created. Valuable and important links do, however, exist between publicly funded research and UK industry. The range of these interactions is large, though some may at first appear to be somewhat subtle. Among the most beneficial links are the skills, the techniques, the instrumentation and the professional networks established by publicly funded researchers, which are taken into industry by individual researchers. Physics and engineering are noteworthy in that the interactions between academic research and industry are especially pervasive.

Generic technology-underpinning research is a proper strength of the universities, extending the knowledge base in key areas, such as materials behaviour, which are and will continue to be of vital importance to UK industry.

The linkages of publicly funded research to UK industry vary in extent from one government agency to another. An area of particular concern is the MoD which is found to draw in more nuclear research from the industrial sector than it yields in return.

### The Respective Roles of Government Laboratories and Independent Research and Technology Organisations

The Institute notes that Government laboratories benefit from the close co-ordinated efforts of their many scientific and technical groups. As such, a modern laboratory provides the possibility of assembling large experimental facilities of exceptional complexity; the ability of individual researchers to meet formally and informally to cross-fertilise ideas; the possibility that such UK centres of excellence will act as magnets to attract world experts to the UK; and the possibility that these laboratories' high scientific visibility will enthuse the next generation of young scientists. Such large laboratories can benefit from economies of scale over an alternative dis-aggregated structure.

The role of most Government laboratories and of many independent research and technology organisations has changed in recent years. As research is a long-term endeavour it is still too soon to judge the full consequences of these changes. The changes in strategy have tended to emphasise technology transfer and more rapid returns. It would appear that there is an increasing transfer of technology into the industrial sector; in a free market of ideas these transfers are not necessarily to UK companies.

### The Operation of Government Schemes Designed to Promote Collaboration in, and Industrial Application of, Research

Even prior to recent Government initiatives the Science Policy Research Unit at Sussex University, in a survey of inter and intra-sectoral collaboration from 1981 to 1991, demonstrated that inter-sectoral collaboration in the natural sciences was strong. They note that university-industry collaboration, as revealed by the published literature, is second only to university-university collaboration, and as such exceeded even university-research council collaboration. Across all sciences SPRU note that university-industry collaboration showed the strongest proportionate increase. Looking in detail at collaboration, SPRU find that physics is the second most collaborative science both in total and in international collaboration. (The most collaborative being "inter-field natural sciences".)

It is particularly interesting to note SPRU's tracking of the balance between collaborative and non-collaborative science over these years. Both in terms of number and proportion of papers there is a clear trend away from single group work in favour of collaborative endeavour.

Privatisation reduced the sum of what was previously public sector research. With the possible exception of BT, the major laboratories operated by those industries have either declined substantially or closed. These laboratories contributed substantially to the national knowledge base, often in generic fields of wide relevance to industry. For instance the CEGB was a prime mover in driving forward the science of fracture mechanics. Post privatisation this area of science is not being pursued.

There appears to be an increasing emphasis on the need for collaborative industrial research to secure European funding. However, European funding is not well suited to producing innovation which can be exploited nationally. There is generally a large overhead in establishing the required industry-industry relationships which must be funded up-front without any indication as to whether costs will be recovered. These factors deter smaller enterprises. Further, the time-scale of decision making is so protracted that companies are reluctant to offer research topics where there is urgency attached to obtaining the results. Shared intellectual property arrangements usually mean that it is sensible for companies to propose only generic topics. Moreover, there is no tax incentive for industrial collaborators to participate in these exercises.

### Intellectual Property Rights and Patenting

There is a tendency in debates on this topic to over-emphasise the issues surrounding intellectual property rights and patenting. Companies appear to place more faith in know-how and ensuring rapid entry into the market. The Institute believes that the best strategy is for companies to be ahead and to stay ahead of the competition.

### The Provision of Finance to Support Enterprises Involved in the Application of Research and Innovation

The Institute is pleased to note the comments in the Bank of England's fifth annual report *Finance for Small Firms,* where it is noted that UK clearing banks are responding well to the challenge of adopting new approaches and developing innovative products to assist in the financing of the technology sector.

Venture capital, bank lending, business angels and other aspects pivotal in ensuring the success of high-technology start-up companies are still areas that could be improved further. It is important that investors realise that returns on physics related high-technology developments can be more rapid than in other sciences.

The Institute concurs with others who take the view that scientists and technologists are undervalued when compared with financial specialists. The Institute recognises that products can only be sold in the market at the market price and if extra money is to be allocated to paying scientists and technologists then economies must be made elsewhere. Despite this, the Institute suggests that the UK should in some way reassess this balance between the remuneration of scientists and financiers.

### The Role of the Foresight Programme in Fostering Networks and Identifying Priorities

The Institute believes that Foresight was an effective way of fostering networks and of beginning to create a vision of a way forward. However, it is important to realise what processes such as Foresight can and cannot deliver and avoid looking to it to solve too many problems. The Institute does not believe that Foresight can, or should, be the main driver of technological innovation in the UK. Foresight is a consensus exercise and innovation is by its very nature not a consensus process. Rarely are true innovators willing to share their perceptions with others (including a Foresight panel) too early.

In discussions of the shape of the 1999 Foresight round with Government the Institute urged that particular care be taken to ensure the involvement of smaller firms. The kinds of large companies that have participated have always engaged in strategic, long-term planning; they probably have less need of a national programme. Smaller enterprises often find it difficult to keep abreast of technological developments and opportunities, yet are sometimes ideally placed to respond rapidly to changing markets. The Institute firmly believes that the knowledge generated by Foresight must be continually updated by the views and needs of all interested

parties. To be effective it should be made available in an immediately useful form. The creation of a Web-based national resource is one ambitious solution.

### The Role of the Engineering and Physical Sciences Research Council in Fostering Technology Transfer

Here, the Institute believes that EPSRC could be more pro-active. The EPSRC could create networks to inform industry of long-term UK research prospects and to create mechanisms to facilitate transfer of both specific ideas and tacit knowledge into industry. These transfers are effectively made when people move from one environment to another. Currently the EPSRC's efforts in the training of post-graduate students and post-doctoral researchers are excellent examples of support for this aim. The EPSRC is weaker, however, in the reverse flow of industrially based researchers into specific university projects and networks. The Institute is concerned that too often university proposals positively supported by industry are rejected on the basis that industry should, if they have that level of interest, finance the work fully.

The Institute applauds the EPSRC for establishing four "Faraday Partnerships" which emphasise the role of intermediaries in the process of fostering collaboration between British research and industry. However, the Institute notes, with disappointment, that the Department of Trade and Industry did not match the EPSRC's commitment in this regard. The Institute is concerned that the four pilot partnerships, with their differing frameworks, do not represent a sufficiently large ensemble on which to base firmly future policy.

In conclusion, the Institute would like to emphasise to the committee that Physicists are happiest when working in a world-wide free market of ideas. Physicists are always open to novel concepts and innovative developments. The benefits of physics to the modern world are massive and complex. The Institute would suggest that rather than attempting to assess the importance of UK publicly funded research in the physical sciences on UK industry the more natural and useful issues are:

The impact of world-physics on UK industry, and

The impact of UK physics on world-industry.

The Institute trusts that UK industry will continue to draw upon innovations in the physical sciences and be receptive long into the future. In addition, the Institute trusts that UK physics will be sufficiently healthy to continue to play its profound role in the technological development of our modern world.

The Institute is a learned society and the professional body for physicists in Great Britain and Ireland, with more than 22,000 members distributed across all sectors of the economy including both higher education and industry. The Institute has approximately 25 affiliated companies including many of the largest high-technology corporations operating in the UK.

The Institute would be pleased to elaborate on any of these matters at the convenience of the committee.

*13 March 1999*

## Supplementary Memorandum submitted by the Institute of Physics

1. The Institute of Physics is an international learned society and professional body for physicists. With over 23,000 members it looks after the interests of professional physicists and promotes physics education and understanding to all. Institute of Physics Publishing, a wholly-owned subsidiary, is a major publisher in physics.

2. The Institute of Physics is pleased to submit evidence supplementary to its submission of 13 March, 1998 [1]. Several developments have occurred in the area of UK innovation policy during the last year. In particular the budget allocations announced from the 1998 Comprehensive Spending Review, the joint DTI-Treasury Green Paper *Innovating for the Future: Investing in R&D* [2] and the more recent DTI White Paper *Our Competitive Future: Building the Knowledge Driven Economy* [3]. In this supplementary evidence the Institute will specifically follow the issues raised by the DTI's Competitive White Paper and refer to the paragraphs of that document in round parenthesis.

### The Importance of University Physics Research to Industrial Innovation

3. The Institute believes that the positive impact on the national economy of publicly funded scientific research has been amply demonstrated [4]. The Institute notes the relative economic decline of the United Kingdom during the twentieth century (1.3), yet today the UK has a world class science, engineering and design base (2.32). The Institute is drawn to question whether the dominant difficulties with wealth creating innovation lie not with the quality of the UK science base but, with the competitiveness of British industry and its ability to draw full benefit from scientific and technological innovation.

4. The Institute reiterates that the greatest economic benefit from publicly funded physics research lies not in the direct exploitation of specific discoveries or the related intellectual property, but in pervasive and intangible benefits. These benefits include the creation of new networks, the development in individuals of tacit knowledge and the transfer of codified knowledge and analytical skills from academia to industry and

the service economy. The outflow of trained people at graduate and post-graduate level is certainly the key output of the university research system [5]. The Institute is encouraged by the mobility of knowledge and has been most impressed by the importance of physicists and physics to sectors as diverse as financial risk management (derivatives), the development of internet communications and innovation in medical diagnosis and therapy.

5. Occasionally specific technologies and discoveries will emerge directly from our university physics laboratories, some of these may spawn whole new industries and government is well advised to foster this process (2.41, 2.42, 2.44, 2.45). The Institute has been pleased to note several key technologies that have spun out of UK university physics laboratories in recent years, to international admiration and acclaim. In particular the Institute notes the recent interest, reported in MIT's magazine *Technology Review*, in the work of Richard Friend and co-workers at Cambridge Display Technology [6].

6. Narin and coworkers of CHI Research in the United States have elucidated some of the key issues involved in understanding better the relationship between university research and industrial technological innovation [7]. These authors have considered the rapidly increasing level of US patent activity and shown that 73 per cent of the research cited by such patents was undertaken not by industry but by publicly supported universities and laboratories. In addition these authors have shown that US firms have disproportionately increased their citation of US and UK academic research while their citation of French, German and Japanese research remains less frequent and has increased far less dramatically [7, figure 1]. The industrial importance to the US of UK academic research is particularly impressive. Narin *et al* highlight a strong correlation between the nationality of patenting firms and the county of origin of the research papers. Therefore it would appear clear that a strong UK science base will indeed be vital for a strong and innovative industrial base in the UK (1.9).

7. The recent surge in patent activity in the United States has itself been the subject of investigation [8]. Kortum and Lerner have concluded that this surge is not a consequence of changes in the US legal framework but, rather, that it does genuinely reflect an increase in US innovation.

8. These studies are also consistent with the view that for physics it is applied science that is closest to industrial innovation as evidenced through patents. It would be inappropriate, however, to conclude that publication in applied physics journals necessarily indicates research groups which have been directed by research managers to focus their interests on solving technological problems. The Institute draws the Committee's attention to the conclusions of Etzkowitz and Webster when they say [9]:

> "The intellectual transformation of the research role of the professor that ensues from the capitalization of knowledge is that instead of thinking only in basic research terms they also think in terms of applied research funding and commercializable results. Rather than auguring a shift from basic to applied research orientation, this broadened focus typically occurs through adding on another activity as faculty adopt a "layered" rather than a "substitution" strategy of research resource seeking and problem selection. Faculty keep their basic research program going but they also add on an applied project and interrogate each research line for implications for the other."

9. In considering issues of technology spin-out from university physics departments it is important that policy-makers do not lose sight of the principal (people-centered) benefits of all university physics research, discussed earlier.

10. There have been several important studies of linkages between UK university scientific research and industry. PREST's recent substantial study considered the areas of expertise of university owned companies [10, Table 24]. The Institute would wish to highlight that the very wide applicability of the discipline of physics may well result in physicists contributing to university owned enterprises in many industrial sectors.

11. The White Paper discusses the importance of collaboration between all stakeholders in the innovation process (3.2). The Institute has long held the view that physics is special in that its applications and relevance pervade a huge range of human activity. The Institute has noted with interest a recent Australian study which has shown that in that country academic physicists (as defined by publication in physics journals) are among the most likely to be pursuing their university research within a department of a different subject [11]. The Institute is keen to ascertain whether this observation would also reflect the position of publishing physicists in the UK.

12. The Institute is conscious that in some cases there is an absence of sound data on which to base science and technology policy. Recognising the importance of post-doctoral researchers and the repeated expressions of concern as to their career development, the Institute has commissioned an extensive study of the attitudes of former post-doctoral researchers to their own career experiences. The Institute's consultants DTZ-Pieda are currently in the process of analysing over 600 responses to targeted questionnaires. The initial report on this study is expected in April 1999. The Institute trusts that this study will help to inform policy with regard to this important part of the knowledge economy. The Institute is pleased to note the interest of the Research Careers Initiative, chaired by Sir Gareth Roberts, in this study (2.43). Sir Gareth is currently President of the Institute of Physics.

13. The Institute would commend to the Government the view of Keith Pavitt (SPRU, Sussex University) when he declares that "the main objective of national policy should be to maintain world class basic research, in the hope that other policies—private as well as public—will get most of British Industry to the world technological frontier" [12].

RECENT POLICY INITIATIVES TO FOSTER TECHNOLOGICAL COMPETITIVENESS

14. The DTI White Paper [3] highlights several recent Government initiatives aimed at fostering high-technology innovation and the knowledge economy. In particular, the Institutes notes reference to:

15. *Public Sector Research Establishments (2.38)*

The Institute welcomes the Government's interest in the commercial development of research outputs in this sector and its plans to consider these matters further. The Institute commends the Rutherford Appleton Laboratory (RAL) for its pioneering relationship with high technology companies such as Ceravision [13]. Companies such as Ceravision and CDT (referred to earlier) illustrate Britain's world-leading expertise in novel display technologies. These technologies are founded on physics and intimately connected with some of the UK's most prestigious research centres (in these cases RAL and Cambridge University Physics).

16. *NESTA (2.39)*

The Institute believes that NESTA has an opportunity to add greatly to the fostering of individual achievement in science, technology and the arts. The Institute aims to engage itself constructively with the realisation of the NESTA concept and plans to respond constructively to the current NESTA consultation exercise. The Institute cautions NESTA not to be overly ambitious and to seek modes of operation that build common ground across all of NESTA's endeavours.

17. *Faraday Partnerships (2.44)*

As noted in the Institute's original evidence, the Institute welcomes the establishment, initially by the EPSRC, of Faraday's Partnerships. The Institute especially welcomes the plans outlined in the DTI White Paper [3] to build a national network of Faraday Partnerships. This should be done from DTI resources rather than from the budgets of Research Councils. Establishing a national programme of Faraday Partnerships lies beyond the resources and missions of the Research Councils.

18. *EU Framework Programmes (2.47)*

The Institute commends the UK Government for its role in successfully pushing forward this vitally important programme during the recent UK presidency of the EU. The EU Framework programmes provide key benefits for UK physics, not only in bare financial terms but also in fostering ongoing and pervasive international collaborations. The Institute notes with interest the thematic nature of Framework 5 and trusts that the Framework process will continue to be receptive to the ideas and talents of physicists.

19. *Foresight (2.50, 2.51)*

Further to the comments made in the Institute's original evidence [1] the Institute is pleased to add that it is an "Associate Programme" of the current Foresight exercise. The Institute aims to be constructively engaged in the Foresight process and to assist with beneficial innovations such as the knowledge pool and Foresight's new thematic structures. The Institute reiterates that it believes that the principal audience for Foresight must be private industry and that the greatest benefit is to be obtained by the smallest companies. Public bodies engaged in supporting academic research must not overemphasize or misunderstand the nature of their relationship to the Foresight concept.

20. *Lifelong Learning (2.56)*

The Institute was pleased to offer evidence in response to the Government's recent consultation document *The Learning Age* [14]. The Institute has emphasised that lifelong learning must not only allow adults to gain vocational skills but must also allow individuals to climb coherent ladders of learning throughout their lives. In this context the Institute is becoming concerned for the provision of regional points of access into physics higher education as smaller university physics departments contract or close their undergraduate programmes.

21. To ensure that the Learning Age is achieved the Government must give urgent attention to the crisis in the recruitment and training of new physics teachers.

22. *University for Industry (2.60)*

The Institute regards the UfI as part of a wider vision for Lifelong Learning in the UK. The Institute commends to those guiding the development of the UfI that physicists in schools, colleges, university and industry have much to offer the UfI project. The UfI must be prepared, however, to cover the full costs of educational innovation by public sector providers. The Institute is concerned that the term "university" in the name of UfI may be a source of confusion regarding this body's welcome purposes and capabilities.

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*4 February 1999*

## APPENDIX 39

### Memorandum submitted by the Institute of Physics and Engineering in Medicine

INTRODUCTION

1. The Institute of Physics and Engineering in Medicine is a registered charity (number 1047999) which exists to promote, for the public benefit, the advancement of physics and engineering applied to medicine and biology and to advance public education in the field, and also to represent the needs and interests of engineering and physical sciences in the provision or advancement of health care.

2. The vast majority of the Institute's members are clinical scientists and engineers working in United Kingdom hospitals or university departments, and many are engaged in research and development in health care applications of physical science or engineering. A few Corporate Members and some Affiliates work in industrial and commercial organisations related to medical physics and bioengineering. The Institute also has a world-wide membership.

SUMMARY

3. This submission deals with the situation concerning healthcare applications of physical sciences and engineering arising largely from the efforts of physicists and engineers employed by the NHS.

4. The underlying problem is the large number of SMEs in the healthcare sector whose successful development is compromised by the lack of large UK companies.

[25] See above.

5. Our Institute, being a registered charity and learned society, is hampered in initiatives, such as our UK Medical Devices Technology Transfer Fair, by being unable to receive support from government schemes.

6. We recommend the formation of networks committed to the dissemination to SMEs of the technologies arising from research and development.

WRITTEN EVIDENCE

*The industrial application of government funded research*

7. A large proportion of the Institute's members working in hospitals as well as universities are active in research in the many specialist areas of physical science and engineering which underpin developments in the diagnosis and treatment of illness and cost-effective clinical services of the future. Original patents for magnetic resonance imaging and computed tomography scanning were filed after pioneering work in the United Kingdom, as were those for a host of lesser known, but equally valuable developments.

8. It is, however, a matter of regret to British scientists that their research and development success has not been exploited by British industry. The medical device industry is dominated by German, Japanese and US manufacturers. There are now no manufacturers of major radiodiagnostic equipment either based in the United Kingdom or undertaking their research and development programmes here. This contrasts sharply with the pharmaceutical industry, where there are world-class companies undertaking research and development and manufacturing work in the United Kingdom.

9. This partly reflects the decline of the British engineering industry. Scientists and engineers working in health care continue to be innovative, but find it increasingly difficult to find suitable British industrial partners willing to develop and market these ideas. The difficulty of transferring technology to the medical engineering industry is compounded by the fragmented nature of this sector, which is overwhelmingly composed of small and medium enterprises (SMEs). This problem could be addressed by strengthening Medilink-type initiatives in this area. At present these help small firms to bring products to market, but they could increasingly be used to address technology transfer issues.

10. When an entrepreneur forms a new company in order to develop a specific medical device which has market potential, he knows that any venture capital involved will seek an early, profitable exit from the venture. For this reason the entrepreneur expects that the company, if successful, may be obliged to sell out to major competitors, all of which are overseas.

*The respective roles of Government Laboratories and independent research and technology organisations*

11. The Government Research Agency with which the Institute's members have most dealings is the National Physical Laboratory, in particular its Radiation Metrology Section. This, however, has now become a commercial organisation and is seeking funding from the National Health Service, rather than being a source of indirect research funding into the National Health Service by being a source of independently funded support services. At present the NPL has a monopoly as the only Primary Standard Dosimetry Laboratory and now that Radiotherapy Centres have to pay for these services, competition in their provision would help to limit cost increases. It is acknowledged, however, that the only present competitive source would be overseas, most likely in Germany.

*The operation of Government schemes designed to promote collaboration in and industrial application of research*

12. A number of initiatives, including ROPA awards, Smart schemes, Link initiatives, teaching company schemes and other methods for encouraging commercial exploitation of research findings have been pursued with limited success. The Institute undertakes unique initiatives in this field, such as the United Kingdom Medical Device Technology Transfer Fairs, held in Durham in 1996 and to be held in Brighton in 1998. However, we find no support from Government schemes because, as a registered charity and learned society, we have not fitted into categories of eligible organisations.

13. Health Informatics, unlike device engineering, represents one area where there are still good prospects for the development of fairly vigorous activity. Also, engineering and physical science partnerships with pharmaceutical companies may offer prospects for increased commercial exploitation in the relatively new fields of bioinformatics, drug delivery systems and sensor technologies.

*Intellectual property rights and patenting*

14. The issue of intellectual property rights for developments within the National Health Service, in particular, needs to be addressed. In general, the NHS does not have the mechanisms in place to protect the intellectual property created by its employees.

15. It is not widely appreciated that cost-effective exploitation of NHS intellectual property can be achieved by use of existing, private-sector technology transfer organisations. This method, pioneered by the

Institute's NHS members, has the advantage of minimal front-end costs. It secures the benefits (in order of importance) of rapid propagation of best medical technological practice, creation of employment in SMEs and recovery of development costs.

*The provision of finance to support enterprises involved in the application of research and innovation*

16. The Institute recommends the provision of finance to networks committed to disseminate to SMEs the technologies arising from research and innovation. Networks should include a lead enterprise and a research provider (academic, NHS, private). The purpose of the support should be to ensure that SMEs have the opportunity to update their technology.

*The rôle of the Foresight programme in fostering networks and identifying priorities*

17. The profession had no involvement in the establishment of the original Foresight programme. It supports the principles of Foresight and would welcome future involvement.

*The rôle of the Engineering and Physical Sciences Research Council in fostering technology transfer*

18. We are not aware that the EPSRC has, to date, played a significant rôle in fostering technology transfer in the health care sector.

*Progress made towards implementing those recommendations of the Science and Technology Committee in the previous Parliament in their report on* The Routes Through Which the Science Base is Translated into Innovative Competitive Technology[26], *relevant to the fields of engineering and physical sciences.*

19. No comment.

*Other issues*

20. It would be helpful if there were improved inter-departmental links between the Office of Science and Technology, the Department of Health, and the Department for Education and Employment, so that resources available for the exploitation of physical sciences and engineering innovations in the health care sector (hospitals and associated university research departments) can be better utilised.

21. The professional status and recruitment of physical sciences graduates continues to be of concern. Job prospects for such graduates will inevitably be limited in the absence of a strong UK employer base. Examples of innovative medical devices that have successfully been transferred into commercial production in the United Kingdom have demonstrated the potential for creating employment opportunities in high technology industries.

The Institute would welcome the opportunity to give oral evidence to the Science and Technology Committee.

*16 March 1998*

## APPENDIX 40

### Memorandum submitted by the Institution of Civil Engineers

INTRODUCTION

The Institution of Civil Engineers (ICE) is the qualifying body for the civil engineering profession. Founded in 1818 and granted a Royal Charter in 1928, the ICE now has over 80,000 members, a fifth of whom are based overseas. The ICE is a registered charity and a non-profit making organisation.

SUMMARY

- Investment by the industry in research and innovation is low, due to low profit margins.
- Dissemination of research findings is poor.
- Long term funding for stated aims, which can only be provided by Government, must be increased.
- Intellectual property rights should remain with the author and patent rights should be the property of the patentee.
- Joint funding is inhibited by companies' lack of motivation.

[26] First Report, Session 1993–94 (HC 74).

— Positive routes for funding by managed programmes continue to emerge. However, less prescriptive criteria for funding are needed, especially to encourage the involvement of small and medium sized enterprises.
— There is a lack of funding for demonstrator or prototype applications of new technological advances.
— The Foresight exercise needs to be improved so as to provide focused aims for future research.
— An emphasis on process rather than technological fix is needed.

1. *Industrial application of Government-funded research*

1.1 Investment in the research and development process and its applications is ultimately financed by the purchasers of products and services provided by the industry. To create and sustain an active research and innovation culture, companies must be able to command sufficient profit margins to support it. Recently, downward pressures and risk aversion in the public procurement of engineering services, particularly in civil engineering and infrastructure, have severely reduced the industry's means and opportunity to invest in development and application of new technologies. The Committee needs to address the impact of public procurement policy and of the need to minimise costs and risks upon the industry's ability to finance technical excellence and international competitiveness.

1.2 The construction industry generally finds difficulty in interacting with responsive mode government funded research as provided to academic institutions. One major problem is that dissemination is not seen as vital by the receiver of funds and will generally be restricted to peer reviewed journals with limited circulation in the commercial sphere. Researchers are not necessarily the best people to disseminate research findings, as a different skill set is needed. Dissemination is a vital aspect of research and should be recognised within separate programmes and budgets which need not be linked to specific research projects.

1.3 Industrial application will occur only if it the client, consultant or contractor gains an advantage by it; with low margins, individual firms are unable to sustain the cost. The effect of low profit is that investment for the future is often not realistic, which results in an inefficient and uncompetitive industry. Generally disseminated information benefits the public at large as the industry becomes more efficient by adopting government funded developments. Particular examples are the long term work of the former Building Research Establishment (BRE) on behaviour of fills and high alumina cements. On topics such as these it is highly unlikely that an individual contractor would have had the range of opportunity or the persistence to provide the necessary long term funding.

2. *Respective roles of Government Laboratories and independent research technology organisations*

2.1 The major construction research organisations have been privatised in recent years, namely the Transport Research Laboratory (TRL), Building Research Establishment (BRE) and HR Wallingford (HR). Other organisations, such as Construction Industry Research and Information Association (CIRIA), British Cement Association (BCA) and Building Services Research and Information Association (BSRIA) undertake the dissemination of information in the form of publications and commission some research projects within the industry.

2.2 Commissioned research within such privatised organisations as BRE, TRL and HR is unlikely to come from individual construction companies. These organisations rely on Government funding to underpin their research, ultimately deriving other income from the knowledge gained. It is beneficial for such institutions to undertake regulatory and advisory research on behalf of Government as a client, but they should also undertake long term projects in support of the industry. However industry funding for such projects is not generally available due to the lack of financial resources. Nor are funds available from other sources for such projects.

3. *Operation of Government schemes designed to promote collaboration in industrial application of research*

3.1 In the construction sector three routes are available to promote industry led collaboration in research.

3.2 The current LINK programmes, *Integrated Design and Construction* and *Meeting Clients' Needs Through Standardisation*, provide funds of up to 50 per cent of the total project value.

3.3 Within the Innovative Manufacturing Initiative (IMI), the *Construction as a Manufacturing Process* programme provides funding for academic institutions of up to 50 per cent of the project value. This programme has been particularly successful in getting the construction industry to think about the processes in which it is involved and has been influenced by bodies such as the Construction Round Table.

3.4 The third route is the DETR *Partners in Technology* programme. Research organisations look to this source for a significant proportion of their funding and compete with proposals from industrial companies on their own or in collaboration with others. Applicants need to contribute 50 per cent of the funding and research organisations generally do not have access to such funding. Industry bodies, suffering from a lack

of available finances, also find such contributions onerous. These conditions often thwart research projects of potential benefit to the industry.

3.5 Industry contributions to such programmes are often in-kind contributions and made by only the very largest companies. Small and medium sized enterprises, whose involvement is a stated aim of the UK Government and European Commission, have even fewer resources to spare and are thus often excluded from participation.

3.6 Although these programmes have rules which can be daunting to the uninitiated, they provide positive routes to allow companies to pursue new ideas. Construction companies interested in developing new products or processes are generally willing to expend staff time and internal resources towards this end but reluctant to commit expenditure to outside bodies.

4. *Intellectual property rights and patenting*

4.1 The ability to retain intellectual property rights for new developments is generally seen to be important. The emphasis is on retaining a market edge by blocking, with licensing rarely taking place or under consideration. Intellectual property rights considerations can be a source of tension between companies and academic institutions but have been satisfactorily resolved in the managed programmes described above.

4.2 Intellectual property rights should remain with the author and patent rights should be the property of the patentee.

5. *Provision of finance to support enterprises involved in the application of research and innovation*

5.1 The *Partners in Technology* programme provides a source of support for the application of research and innovation against relevant case studies. As currently constituted only the LINK programmes, which are limited in scope, allow partial funding for organisations committed to research and innovation. Funding bodies' concerns over incremental research and fear of substitution of funds have resulted in a lack of funding for demonstrator or prototype applications of new technological advances, which are likely to be necessary to persuade a conservative industry to adopt new ideas. If the IMI programme was not restricted to the funding of research academics it could provide a substantial boost to the industry's research and innovation efforts. If the market opportunity arises and the means of application exists there will be no need for each provision. The market will promote applications; what is needed is consistent and secure funding for long term projects with defined objectives.

6. *Role of the Foresight Programme in fostering networks and identifying priorities*

6.1 The first Foresight exercise is generally regarded as flawed in its approach to construction because the industry is so wide-ranging. The statements which emerged from the Delphi exercise were criticised as bland and uninspiring. This aspect is currently being addressed and if the Foresight programme can provide radar warnings to future directions and opportunities for particular sectors of the industry it will be regarded as successful.

7. *Role of the EPSRC in fostering technology transfer*

7.1 Technology transfer is not well established in the construction industry but the use of the Technology Transfer Scheme should be encouraged, especially as more companies engage in managed programmes. The role and applicability of the Faraday Partnerships scheme has had little impact and is not well understood by the construction industry.

7.2 The White Paper on Science, Engineering and Technology emphasised the need to harness academic research for wealth creation. However the proliferation of schemes to involve industry have different rules and different complexities which create obstacles to companies that may otherwise wish to become involved. Exchanges between industry and academic personnel are desirable, but schemes promoting this approach need to be properly financed to be successful.

7.3 Managed programmes should be encouraged and expanded but balanced with continuing support for high quality responsive mode research. The additional administrative burden of managed programmes needs to be acknowledged and accepted.

7.4 EPSRC managed programmes provide a means for sustaining long term programmes of research and centres of excellence, and should be encouraged in this role.

*10 March 1998*

## Supplementary Memorandum submitted by the Institution of Civil Engineers

The comments below are recommendations from the ICE-led project "Technology Support for Civil Engineering Exports" published in September 1998 by Thomas Telford.

### 1. Global Competition. UK Industry Must Compete Globally by Adding Intellectual Value. Industry and Government Investment Must Focus on Technologies that Create or Maintain a Leading Edge.

Civil engineering design and construction markets worldwide are becoming more competitive as more players from more countries seek work overseas. The UK market for consulting, contracting and materials supply is open to international competition and major UK companies cannot survive by relying on UK work; they must maintain and grow their already substantial international presence and maintain their competitive advantage through substantial financial resources and a technological edge.

It is no longer viable for the industry to compete in international markets on the basis of standard technology and provision of basic engineering services—"we cannot compete at the nuts and bolts level". The speed of dissemination of information and worldwide expansion in technical education and availability of professional skills, means that standard solutions can be designed and constructed without the need for UK input. Therefore, UK industry needs to concentrate on adding intellectual value and providing original and innovative ideas and solutions. This requires constant investment in research and the application of technologies to maintain a leading edge for the UK civil engineering industry.

### 2. IR into DA. There is a Great Challenge to Translate Innovation and Research into Development and Application. A Higher Proportion of Industry and Government Resources for Technological Development Needs to be Focused on Development and Application.

Innovation, Research, Development and Application (IRDA) are about translating ideas into practice and the process through which competitive technologies evolve. The key to success is to provide a climate for innovation and then the financial means and incentive to push innovative solutions through into technology for application. "For every £1 spent on research, £5 needs to be spent on development and application," but companies do not have substantial budgets for implementation of research results and "everyone wants new technology, but not on their project first". Recent initiatives such as the "Best Practice" programme aim to bridge the gulf between IR and DA. Bridging the gulf is a core requirement if technological competitiveness is not to be stifled and competitive advantage lost.

### 3. Strategic Research. A New Industry-Government Partnership Needs to be Forged for the Long-Term Maintenance of Centres of Excellence.

Government support of research centres of excellence has been of immense value to the industry and to the UK economy by maintaining the industry's technological edge. The industry cannot replace this level of investment from its current slender profitability. However, the UK's leading edge and intellectual capital will be jeopardised unless investment is maintained. A realistic industry-Government partnership is needed for the long-term funding and maintenance of strategic centres, which provide problem-solving experience and technical know-how that underpin the industry's reputation.

To optimise the use of finite resources, the whole industry needs to be engaged in a co-ordinated and co-operative plan to work with Government through CRISP (the Construction Research and Innovation Strategy Panel), Foresight, Partners in Innovation and the Research Councils.

### 4. Demonstration Projects. Industry has to be able to Demonstrate New Technology, Successfully Applied in High Profile Projects. Clients, Including Government and the Industry, must Develop Mechanisms to Enable New Technology to be Applied, Tested and Proved on "Home Market" Projects so that it can be Offered Successfully in Export Markets.

Potential overseas customers are influenced by high-profile projects that demonstrate technological success but the application of new technology in the design and execution of high profile projects inevitably carries risk. Clients tend to be increasingly risk-averse and as the finance and procurement for public projects has moved progressively to private sector organisations, so the opportunities to prove innovative solutions using new technology are less widespread. Projects that demonstrate the successful application of innovative technology are extremely important for credibility and success in export markets. There has to be a way of valuing and if necessary supporting innovative first implementation of technology over and above least-cost, least-risk considerations.

5. Integrated and Adapted Technologies. The Future Lies in the Integration of Design and Construction, with Adaptation to Local Circumstances. The Industry and the Research Community Should Seek to Advance and Exploit Those Areas Where it Finds it has, or can Gain, Real Technical Superiority, Including the Creative Application of Existing Knowledge and Research Results.

Although each sector reviewed has produced its own specific technology priorities and needs, a common theme is the need to integrate technologies to deliver whole solutions, to adapt them to local needs and circumstances and to demonstrate their ability to work as a team of infrastructure providers. This is the added intellectual value that gives the UK industry extra competitiveness. There is a wealth of existing knowledge and research to be mined, developed and applied and such an initiative does not depend wholly upon extensive investment in new research programmes. It is not necessary to be ahead in every aspect of industry technology; a narrow but appropriate technical advantage can be sufficient to win a broadly-based project.

6. International Standards. Government and Industry Should Lead the Development of Civil Engineering-Related Codes and Standards Where they have a Value in Winning Overseas Contracts.

Promulgation and adoption by other countries of civil engineering-related codes and standards based on UK national equivalents give a clear advantage to UK companies and play an important part in exporting of civil engineering services, but this needs to be better understood by industry and government. Nationally, the UK is neglecting standards development through a lack of resources even though many UK engineers are still involved in this work. Many developing countries are preparing their own standards, despite resistance from the World Bank. The new Eurocodes, when finalised will also be used increasingly worldwide. The UK needs to maintain a position of leadership in the formulation of civil engineering-related codes and standards and be active in international regulatory bodies such as CEN and ISO.

7. The Role of Specialised Technology Companies or Groups. Technological Advances Often Originate in Specialist Companies or Specialist Groups Within Large Companies. Such Specialists Often Need Special Resources for their Innovation, Research, Development and Application (IRDA).

UK civil engineering is a large industry led by a powerful international multi-disciplinary companies. Whatever their strengths such companies often rely on specialist technology companies and/or specialist groups within the firm to provide leading-edge technology for major projects. Such companies and groups have the ability to work in highly specialised technical niches and to adapt quickly to changes. The industry needs them as a source of innovative technology, but such companies and groups need the financial resources to maintain their technical evolution by the acquisition of knowledge and its application in engineering practice. They should not be discriminated against on grounds of size in the allocation of government research sources. They need to be able to sell their specialist skills and knowledge at margins that enable internal investment in technological advances to continue.

8. Measuring Success. Government and Industry Should Collaborate to Develop a New Approach to the Measurement of Industry Success Overseas.

Technology adds value to activities rather than delivering direct benefits and it is often difficult to establish its effect on the bottom line of company accounts. In addition, the trans-national ownership of civil engineering organisations through mergers, acquisitions and alliances obscures the true value of overseas business to the UK economy. Analysis of the published data identifies many apparent peculiarities and distortions. Measurement of the impact of this project and the implementation of its recommendations, need a framework for recording value returned to the UK economy from overseas projects undertaken both by UK-based companies and by UK companies collaborating with UK or overseas partners.

*1 February 1999*

## APPENDIX 41

### Memorandum submitted by the Institution of Electrical Engineers (IEE)

Introduction

1. The IEE is the largest professional engineering institution in Europe with some 140,000 members. It represents the electrical, electronic and manufacturing science and engineering sectors in matters of public concern, as well as accrediting degree courses and promoting science and engineering education in schools. Our members work in both the research and industry sectors and can thus comment with some authority on innovation and technology transfer.

SUMMARY

2. The inquiry into the innovation and technology transfer in the fields of engineering and physical sciences covers a wide spread of Government funded research ranging from Government contributions to EC programmes, DTI funded initiatives, MoD research and work sponsored by other Government Departments such as Department of Transport and the Home Office. Companies develop new products in three principal ways: as an extension or development of an existing product, where little help is sought in product definition but Government sponsorship may play a role; as a new idea to meet a previously unsatisfied requirement, where Government funding of pre competitive research may have an influence on this area of activity; or as a result of customer funded product development, where Government funding may have been very beneficial. There is no doubt that Government programmes have a beneficial effect on the development of key processes and products in industry. Industrial laboratories focus on the business case for their internal research and development programmes seeking a strong internal justification for their activities. It is also apparent that the larger companies, to a varying degree, see themselves as international players and they do not look solely, or in some cases even predominantly, to the UK for their sources of technology, inspiration and innovation. Against this background, it is difficult to answer many of the questions raised since they appear to be framed upon assumptions that may be incorrect.

3. However, the availability of funding from Government sources and the benefits of collaboration as a means for widening their knowledge have frequently influenced the pattern of their R&D programmes. The greater part of the Government sponsored programmes are currently collaborative in nature. This has the advantage of widening the intellectual base of the programmes and of creating networks of scientists working in similar fields. However, it has the disadvantage of considerably increasing the administrative overheads in establishing the programmes. This is because it is difficult to generate programmes in which a disparate set of organisations each benefit equally; the intellectual property and exploitation rules must be established between the parties before the programmes can be launched; many of the programmes operate over several years and companies operate over a one year budgeting cycle. Hence funding difficulties can arise within one or more of the participating companies which affect the whole programme after the first year. For EC sponsored programmes, management and reporting of an international collaborative programme create a major overhead on the programme.

4. Other than at the basic components end of the sector, the technology based industries sell products or services which rely on the assembly of many components derived from many core technologies to form complex systems. As a result, it is unusual for a single advance in basic research, leading to a better or new component, to lead directly to a new product or service. Nevertheless, without continuing advances in components and core skills, competitiveness of products or service offerings would not be maintained. Nor do such developments occur without innovation and breakthrough at the material and device level. However it does mean that a given company must focus its attention on the critical core competencies for its product or service and not attempt to duplicate those which it can buy in via a multi-vendor market. As a result of this, it is particularly difficult to identify what basic research is important in support of a given sector since even similar companies within that general sector will often have chosen to focus on different core skill sets in order to enhance their own chosen access to that market. Their choices are based upon assessment of their product offerings, their assessment of how they can fit into the market against other competitors, how they can differentiate themselves from competitors, what technologies they can acquire by strategic alliance or straight purchase and what traditional strengths they have developed. Such decisions are very company dependent and even large companies (in UK terms) show very clear evidence of such focusing in the R&D portfolios and thus differences in positioning.

*Industrial Application of Government Funded Research*

5. Government funded research in the Defence sector is clearly influential in the decision process for new products in that field. But, with the total Defence R&D budget decreasing in real terms, the UK is in a disadvantageous position with respect to its international competitors. The result is that insufficient research and feasibility demonstration is done at the early stages of a programme, which can give rise to technical difficulties and consequent delays later in the programme. In other sectors industry is tending to fund the research itself. This gives industry much more control over what is done, ensures that it is well defined, and provides unique access to designs, patents and intellectual property. Individual companies do establish working links with university research departments which are doing exploratory basic or strategic work relevant to their interests. This serves to give them a longer term and sometimes wider International window on the subject. This gives them the opportunity to seek answers to questions that they cannot take time to evaluate themselves. They also benefit from wider collaborative groupings. In addition to outcome in the form of Patents or other IPR there are also valuable elements such as better product development decisions by the company, which result from a wider understanding. These elements may be of great value to a company but do not show in its portfolio. Effective application could be improved through a sharper market focus, and better balance and coordination of technology transfer and postgraduate training within universities.

*The respective roles of Government Laboratories and independent research and technology organisations*

6. Government laboratories have a role in carrying out work that for reasons of National Security, to meet regulatory requirements or efficiency of resource utilisation cannot be done elsewhere. These operations may be conducted under high security which is not necessarily conducive to easy technology transfer.

7. The independent research and technology organisations (IRTO) do have a clear role as contract research organisations, providing a service to industrial companies, many of whom may not be able to justify their own in house research. Their activities are frequently short term and they can respond quickly. The independent laboratories are able to provide specialist input in their areas of expertise. It is of concern to industry that these organisations are increasingly taking on overseas contracts. The distinction between Government laboratories, particularly those which now operate as Agencies and the IRTOs is becoming increasingly blurred as they both seek contracts from industry on a strictly commercial basis.

8. Priority in both cases should be to meet "Customer Needs" for knowledge and skills. Excellence, relevance and lack of direct duplication should be the key determinants of programmes.

*Operation of Government Schemes Designed to Promote Collaboration in an Industrial Application of Research*

9. These schemes can be very useful but to draw maximum benefit from them the schemes should be run by people with industrial experience. However, evidence shows that the EU collaborative research schemes are rather inefficient and slow moving and the requirement for "juste retour" is a major distorting factor, detrimental to rapid progress. We have no argument with the principle of collaborative schemes, but the proliferation of very small tightly focused programmes, involving many participants, each with its own set of particular rules, including deadlines, programme guide etc, is extremely damaging and counter-productive. Many of the schemes require around 50 per cent input by the collaborating industrial body. In some circumstances the industrial bodies have seen the government funding as a way of off-setting their potential costs rather than a way of technology transfer from the location of the initial research, often in Universities. Simplification of the whole programme structure would be helpful. Government should be prepared to fund a greater part of the applied research (near market) and postgraduate teaching load, neither of which sit comfortably in industry in a competitive world market.

*Intellectual Property Rights and Patenting*

10. Patenting is hugely expensive and many companies choose not to go down this route. Software is covered by copyright rather than patent law which is much cheaper and since much research presently entails design, simulation and software rather than hardware development, it is much easier to retain the intellectual property rights on such research. However this mitigates against a culture of manufacture and production and instead guides research towards software development and simulation. In the current climate this may be the correct thing to do but Government ought to be aware of the direction in which research is going. The use of IPR varies widely from industry sector to sector and company to company. With many sectors speed to market and the associated "know-how" is a more important factor. HEIs should have the opportunity to exploit IPR, thus generating royalty revenue, but it should also be recognised that real return is via the manufactured service or product.

11. Government generated intellectual property should be protected and should be made available for exploitation as appropriate. Royalties and other terms and conditions would need to be agreed in advance taking full account of commercial considerations and opportunities.

*Provision of Finance to Support Enterprises Involved in the Application of Research and Innovation*

12. Although financial support may be considered poor when compared with European countries the Enterprise Investment Scheme has been a good source of finance for high-technology start ups and should be simplified and extended. Funding should be via the Venture Capital market. If the conditions of this are too onerous, then there may be a case for examining tax-incentives to encourage investors to invest in more speculative ventures. Currently much luck is involved in the inventor of a particular process, component or piece of software achieving industrial backing to develop the product to marketplace. The old system, of what was essentially a venture capital fund administered by government, was not perfect but certainly provided a focus and a direction in which the inventor could go to try to obtain financial support for further development of his invention. Funding should be such that it does not encourage the establishment of companies, by academic departments, without a sound business case.

13. Capital markets will fund innovation but not postgraduate training and applied research. The knowledge and skills base required by industry is largely a community responsibility. Much of industry is becoming global and companies are moving their R&D activities to countries where knowledge and skills are most readily available.

*The Role of the Foresight Programme in fostering networks and identifying priorities*

14. The Foresight programme has been fragmented within the Universities and has been largely ignored by industrialists. There is a view that industrialists will undertake work defined under the Foresight programme if such work coincides with their interests. They are unlikely to alter the direction of industrial development or to adopt new areas of technical enterprise merely because of the Foresight programme. The Foresight scheme has provided some additional networking opportunities, especially for those invited to join the panels. But overall there has been little relevance to the innovation process. It has had no significant impact on identifying priorities although it is obviously a matter of concern that the Research Councils claim that it has and act on this assumption. This concern arises from the now very outdated conclusions of the exercise and their generality. The reports, although interesting reading, contained little that was innovative and gave no new deep insight into the future. This was, perhaps to be expected as it is unlikely that researchers and industrialists would have given away their best ideas. Foresight's strength was in networking and has led to a move towards improved business processes. There is a need for Government to move closer to the market in research and training and an important role for the future Foresight exercise is to help Government with the industrial policy and investment decisions involved.

*Role of Engineering and Physical Sciences Research Council in Fostering Technology Transfer*

15. Although the EPSRC has recognised the importance of industry/university interactions in recent years, more could be done. It is probable that new centres for training and applied research are needed, with a strong element from industry, in the appropriate market sector. There is a need for members of assessment panels to have in depth knowledge of the appropriate sector. Many university-based inventors have moved away from EPSRC for technology transfer support because of the time-scales involved. Industrialists want a fast turn around and reduced time to market in order to ensure market share of products developed. Direct funding by industrialists or by venture capitalists is often the preferred method. We would recommend that the EPSRC evaluates its procedures to ensure the most effective route for industry/university collaboration.

*Progress made towards implementing those recommendations of the science and technology Committee in the previous Parliament in their report on the Routes Through Which the Science Base is Translated into Innovative and Competitive Technology*[27] relevant to the fields of engineering and physical sciences

16. There do seem to have been some areas of progress. However it is regrettable that Science and Technology no longer rates a ministerial position exclusively devoted to it, and this has led to a lack of focus. The OST and Foresight have helped but industrial R&D has declined as Government has continued to withdraw from near market research. There is a belief that by starving the ducks, only the really fit will survive; this ignores the truth that not even half starved ducks compete successfully with well fed ones. There is a danger that the HEI research base is being rapidly eroded.

*March 1998*

**Letter to the Clerk of the Committee from Dr L Goldstone, Deputy Secretary, the Institution of Electrical Engineers**

Thank you for your letter of 15 December 1998 addressed to Dr Williams, which has been passed to me for attention.

Since preparing our original submission last March, we have noted with satisfaction the increasing emphasis which the Government is placing on the importance of science, technology and engineering to the well-being of the UK. We are particularly pleased that Lord Sainsbury has been appointed Minister for Science at the DTI. Thus, we would perhaps have wished to reflect this change in paragraph 16 in our submission[28]. Other than that, we have nothing further to add.

## APPENDIX 42

**Memorandum submitted by the Institution of Mechanical Engineers**

INTRODUCTION

The IMechE is a registered charity, representing the interests of over 80,000 professional engineers and students in the field of Mechanical Engineering.

Through its Boards, Committees and permanent staff it is actively engaged in promoting the dissemination of technology, setting and monitoring standards in higher education and training and forging links with Industry, Academe, Professional Engineering Institutions and Government.

[27] First Report, Session 1993–94 (HC 74).

[28] See above.

SUMMARY

The IMechE welcomes the inquiry. The steady flow of innovative ideas into industry is vital to establish leading edge technologies and world class manufacturing.

SPECIFIC COMMENTS ON INFLUENCING FACTORS

1. *The Industrial Application of Government Funded Research*

IMechE endorses the relevance of this factor, and assumes that data is available to show a track record of performance i.e. evidence of yield to UK plc. Government funding has a role to play in situations where the capital value of research equipment is beyond the resources of the private sector to finance in terms of a return on capital employed. "Big Science" falls into this category and there are some facilities which are unique, in some cases by default, because the rate of usage does not justify replication. There are some examples of this at the Rutherford Appleton Laboratory.

2. *The Respective Roles of Government Laboratories and Independent Research and Technology Organisations*

IMechE endorses the relevance of this factor; there is an increasing trend by major industries and tier one suppliers to place "application" contracts with independent R&D Organisations; the underlying reasons will be of value to this inquiry.

Where Government funding can play a key role in helping industry is in providing seedcorn funding of development projects which might not otherwise go ahead. However, the level of funding needs to be a substantially higher proportion of the project costs for SMEs than for larger companies.

3. *The Operation of Government Schemes Designed to Promote Collaboration in-and Industrial Application of Research*

In situations where a number of companies have a common interest in a particular topic, the formation of a JIP (Joint Industry Project) can be a very effective way of carrying out pre-competitive research. The JIP can be managed by a third party such as an independent research and technology organisation or a specialist consultancy company. These might also undertake much of the research under contract to the consortium of sponsoring industrial companies. Such organisations are much better suited to carrying out focused industrial research to tight time scales than are the Government Laboratories.

4. *Intellectual Property Rights and Patents*

It is important to establish the Intellectual Property Rights status at the commencement of a Joint Industry Project, as it is for any contract research carried out in the public or private sectors. Some private sector organisations will of course provide an advisory service for exploitation of IPR, including patents, and may also take specific products or processes through the first stages of commercialisation on a "risk and reward" basis. Again it is the smaller companies that are in need of greatest financial help in taking forward innovative ideas from concept to design and implementation.

5. *The Provision of Finance to Support Enterprises Involved in the Application of Research and Innovation*

IMechE perception is that this (ie application) is already covered within 3 above. IMechE recommend that 3 addresses "collaboration"; and 5 addresses "application". Alternatively, redefine these factors so that ambiguity is removed.

6. *The Role of Foresight Programme in Fostering Networks and Identifying Priorities*

The Foresight Programme has so far played only a minor role in fostering networks. It was seen by many as "high level" ie of interest to larger organisations with longer term strategic objectives but of little relevance to smaller businesses, particularly SMEs. This needs to be taken into account in the second Foresight Survey. However, the adoption of a market sector approach and identifying key technologies within each sector was undoubtedly better than the converse of pursuing technologies only, as has been done in Foresight exercises, in some other countries.

We believe it will be essential at the commencement of the next Foresight survey to consider how the outputs will be disseminated and implemented. The first exercise has already had a considerable amount of influence on the spending priorities for Government-funded R&D. For example, the Foresight recommendations are regularly quoted in research proposals submitted to the various Research Councils. If the second exercise is more detailed and less "high level" in its approach than the first, its outputs will be more relevant to a wider range of smaller companies. This must be recognised at the outset and plans put in place to alert the wider business community to the benefits of Foresight and its processes.

7. *The Role of the Engineering & Physical Sciences Research Council in Fostering Technology Transfer*

Through funding various Industry/University research schemes such as the Teaching Company Scheme, CASE Awards, etc the EPSRC plays a modest role in fostering technology transfer. The major components of technology transfer are people and software. In this respect, EPSRC plays a vital role in managing the funding of research projects at Universities and Government Laboratories which produce technologically trained people and engineering/scientific software which can be taken up by industry.

Overall, the IMechE considers that formulation of a new strategy will be critically dependent upon the cost effectiveness of prior schemes and processes. Government must develop mechanisms of confidence weighted risks and benefits before funding.

*6 March 1998*

## APPENDIX 43

### Memorandum submitted by the Institution of Professionals Managers and Specialists

1. The Institution of Professionals, Managers and Specialists (IPMS) is a trade union which represents 78,000 scientific, technical and other specialist staff in the civil service, research councils and other related public organisations and an increasing number of private sector companies. Of particular relevance to this inquiry is the fact that IPMS represents scientific and professional staff in the remaining government research establishments (GREs) and Headquarters divisions and regional offices in the Department of Trade and Industry (DTI), in the Ministry of Defence (MOD) and in the Department of Environment Transport and the Regions (DETR). We represent the scientists in most of the research councils including EPSRC and PPARC relevant to this inquiry and in the UKAEA; also in newly privatised organisations such as AEA Technology, the National Physical Laboratory and Laboratory of the Government Chemist. We also represent scientists in GREs associated with the Home Office, eg the Forensic Science Service. IPMS also represents scientific and other technical and professional staff in the British Technology Group, the Patent Office, and in the British Library Technical Services Directorate, all of which have an important role to play in technology transfer.

#### Summary

2. Our evidence notes that despite welcome developments such as Technology Foresight there is still insufficient investment in research and development and its application, particularly in the physical and engineering sciences, whether by government or industry. As far as the people in engineering and physical sciences are concerned major areas of their employment have been drastically reduced and this is reflected in, although not the only cause of, the declining popularity of the physical and engineering sciences within the proportional decline in popularity of natural and mathematical science in general compared to Arts. This is potentially disastrous in a world where it is now commonplace to state that people are our main source of competitive advantage and where "making knowledge productive is key to business success". IPMS believes that the reliance on the free market is inadequate to turn the situation round and that government should give a strategic lead.

3. In particular the position of Chief Scientific Adviser to the DTI should be reinstated. The Technology Foresight process and the "business links" and innovation schemes should be provided with more infrastructural support and with delivery systems which are more closely geared to the needs of weaker areas, particularly SMEs. The ability of the Cabinet Minister for Science, the Science Minister and the Chief Scientific Adviser to coordinate science and technology policy across departments should be strengthened so that the full scientific resources of government can be brought to bear on science, technology and innovation strategy. That strategy must include much greater systematic attention to training, careers, and continuing professional development of science and technology staff.

#### The Industrial Application of Government Funded Research

4. The total amount of government funding available for research has declined over the last 15 years. Although the "science vote" for universities and research councils was increased slightly in the last few years in real terms it is now on a downward path again. Moreover the two thirds of government funding which comes from other departments has declined steeply (see Table 1). As the Dearing Committee is only the latest to point out this has resulted in a deterioration in equipment and other aspects of the research infrastructure requiring an estimated £500 million to put right. As Sir Ron Dearing himself said in evidence to the House of Lords Science and Technology Select Committee "... while there has been a very good record of achievement, there is a much less satisfactorily record of maintenance of the capability to conduct research in the future. To an extent my own judgement would be that we have achieved the very high level of performance by eating into capital that was created in the past, in terms of buildings, infracture and research equipment. As a result we now have a worrying position."

5. Industry has stressed the major importance they attach to a healthy science and engineering base able to pursue long term curiosity based and strategic research. However, they have not welcomed the Dearing proposal that they should help pick up the tab. A healthy science and engineering base is also a vital component in attracting inward investments from overseas which is increasingly filling the gap in funding left by industry and government.

6. A healthy science and engineering base is also critical to enabling UK Ltd to interpret and apply discoveries and made elsewhere, ie the "intelligent customer" role. This argument also applies to industry R&D. If companies do not have an active R&D function it is more difficult for those companies to understand and apply research findings from elsewhere or to bid for the funding available from government schemes. Most people including the Treasury now accept that both for economies as a whole for and individual companies there is a close correlation between the amount invested in R&D and their long term growth and prosperity. In the UK Business Enterprise R&D as a percentage of R&D declined from 1.47 in 1988 to 1.34 in 1995 and is currently the lowest of the major industrial economies. (see Table 2).

7. Over the period 1989 to 1996 UK government funding for R&D performed within UK business declined in absolute terms from £1,312 million to £885 million. A small proportion was replaced by EC funding (automatically replacing the UK Government funding by the Treasury policy of "attribution"). But the biggest growth was in overseas funds which grew from £1,023 million to £2,010 million over the same period. Industry's own contribution to R&D remained static in real terms and represented 62 per cent of all the sources of funds for R&D in UK business in 1989 and 61 per cent in 1996. The R&D Scoreboard has shown a similar pattern of low investment in R&D by industry itself, particularly by comparison with competitors abroad. The UK continues to have the lowest ratio of R&D to sales of any G7 country and recorded a low increase in R&D spend since 1992 relative to the USA, Switzerland and Sweden. For most sectors with the possible exception of pharmaceuticals the UK continues to underperform its major competitors in R&D commitment. Table 3 shows the generally poor position of physical and engineering science areas in this respect.

8. We also need to take account of outputs as well as inputs and a recent DTI paper "The Quality of UK Science" has attempted to measure the performance of the UK science base compared with that of other countries by use of the citation index. Overall on this index the UK ranks 5th compared to 12th on the R&D/Sales Ratio among OECD countries. For science citation the UK is in the top six in 15 of our 20 scientific fields with clear strengths in plant and animal science, agriculture, pharmacology, neuroscience, biology and biochemistry, mathematics, microbiology molecular biology, genetics and psychology/psychiatry. Our relatively weak areas include chemistry, ecology, engineering, physics and computer science.

9. Further analysis of the citation index by Hicks and Katz. ("The Changing Shape of British Industrial Research") shows that there has been a decline in AEAT, electricity and electronics citations—changes which they say may be related to the decline in defence R&D, and to privatisation. As the R&D scoreboard itself has shown privatisation has often been followed by a cut in R&D expenditure and staff. There are therefore major funding and structural issues which need to be addressed, in addition to the more detailed factors set out below, if the UK is to use R&D effectively and remain competitive.

### The Respective Roles of Government Laboratories and Independent Research and Technology Organisations

10. The previous report by the committee (para 150) emphasised the important role of RTOs and Government Research Laboratories especially as "intermediate organisations sitting between HEIs and industry". This role remains crucial. However the previous report by the committee emphasised that the GREs' role went much wider than that of a research contractor. They were often a valuable part of the science and technology base and guardian of national standards, as for example in the case of the National Physical Laboratory.

11. Since the last report of the committee on this subject most of the Government Research Establishments in the engineering and physical science area have been privatised. Of the DTI laboratories AEA Technology, the National Physical Laboratory, the Laboratory of the Government Chemist, and the National Engineering Laboratory have been privatised leaving only the small National Weights and Measures Laboratory within the DTI. The Transport Research Laboratory and the Building Research Establishment have also been privatised leaving the new DETR with no in house laboratory (except the HSE laboratory which was recently transferred with the Health and Safety Commission from the Department of Employment to Environment).

12. No doubt the Committee will be inquiring into the role which those privatised laboratories are now playing. They will continue to fulfil an important role vis à vis industry similar to that of RTOs. We suspect, however, that there is no longer the easy access to their advice by government and the distance between them will increase over time as each privatised organisation becomes less able to reply on government funding and increasingly has to seek contracts were they can find them. It would also be useful to know to what extent the national standards role is still being fulfilled by the NPL and LGC in particular.

13. As a result of the privatisation of these major laboratories science within government has lost critical

mass. The DTI and DETR are mere shadows of their former selves to the detriment of the "intelligent customer" role and their ability to respond to political and industrial needs. Indeed, there was an internal report on the Transport Department before the election which said that because of the lack of scientific and technical expertise within the department they were losing credibility and intellectual weight in both UK and EU deliberations. Since the election the amalgamation of the Departments of Environment and Transport has exacerbated the situation as they try to make further savings. Not only is this a critical loss of scientific influence within departments, it also means the Minister for Science and Chief Scientific Adviser have few resources to call upon within the government machine. As a result the research councils, being the only area under the direct control of OST are being used as the main instrument of government science and technology strategy.

14. It is absolutely vital that the major GRE still left in government which is involved in the engineering and physical sciences and industrial innovation—the Defence Evaluation and Research Agency (DERA) should not be privatised. The MOD and DERA have moved some way towards the objective set out by the last committee report that they should be as helpful to UK industry as the Department of Defence is to US industry. Indeed now that DERA is to become the centre for defence diversification initiatives its role in civil/military technology transfer will increase. It is vital that it retains a strategic and accessible role within the public sector.

15. The great majority of MOD scientists now work within DERA. There is a significant interchange of staff between DERA and mainstream MOD, particularly with the Procurement Executive. In addition, DERA is by far the MOD's main source of senior scientific policy advisers. The loss of this interchange and source of scientific expertise to MOD policy making would be extremely detrimental. Last year's National Audit Office report recommended that MOD should strengthen its "intelligent customer" capacity. Currently DERA acts in many respects as part of MOD's intelligent customer role. Independent technical expertise is essential, not least because of the reduction in competition through national and international mergers. In particular, international mergers may create industrial prime contractors that cannot be guaranteed to have the best interest of the UK at heart. A privatised DERA, in competition with other Defence companies, clearly could not play this intelligent customer role for MOD, resulting either in the need for a substantial transfer of staff back to MOD, or the duplication of the expertise within MOD, with an obvious impact on costs.

## The Operation of Government Schemes Designed to Provide Collaboration in and Industrial Application of Research

16. IPMS welcomed the emphasis placed by the DTI over the last few years on changing the culture of industry and helping to diffuse innovation more widely including among SMEs. However it should not have been at the expense of direct funding for research in industry. "Business links" are an important part of that strategy. We agree with the previous recommendation of the committee that "business links" should be able to provide information about national as well as local sources of technological expertise and the data bases necessary for this should be developed. It is also important that technology counsellors should be closely linked to the centre in DTI so that they can feed back information to influence policy. We do not believe that the situation on resources has improved, indeed it may have worsened. As we understand the situation there are no national comprehensive information databases within DTI and there is still no leadership from the centre or expertise in depth at the disposal of the "business links".

17. It is vital that the DTI's strategic role in innovation be strengthened. There are many issues which cannot be left to local and regional arrangements or to market "push". The post of Chief Scientific Adviser to the DTI should be reinstated to give more strategic advice and direction to support for innovation as well as boosting the science and engineering knowledge base.

18. As far as collaborative schemes are concerned there is probably scope for further streamlining and a relaxation of partnership criteria, especially since the status of many laboratories has changed over the years through privatisation.

19. On structuring of funding in general we have reservations about the increasing use of competitions for "Challenge funding" and "prizes" of various sorts. Often they are relatively small packages of support and can take a large amount of time to compete for them. This is a particular difficulty for SMEs many of whom do not have the infrastructure to apply or even to know of their existence.

20. It is also important to have a "level playing field" in applying for research contracts and greater stability of funding. This is not specific to collaboration schemes as such but applies to contracts for research whether placed by industry or Government. The last report of the Committee said that industry must be prepared to pay the full costs of the near market research it contracts to universities.

21. This should also apply to government and other "purchasers"/customers. The Dearing Committee has referred to the need for research councils to fully fund indirect costs. Moreover, when the customer/contractor principle was first introduced following the Rothschild report in 1972 customer departments were supposed to provide an additional amount (the "Rothschild 10 per cent") to cover the maintenance of the core science base within the PSREs who were acting as contractors. This principle has rarely been honoured but it should

be. If the contract based system is to work it needs to have clear rules for contractors and customers in order to maximise continuity, exchange of information, and stability of income streams, and to ensure a degree of reciprocity in opening up areas to contract bids whether this be within the UK or the EU.

### Intellectual Property Rights and Patenting

22. The Patent Office plays an important role in promoting knowledge and positive attitudes towards intellectual property in both industry and academia. Its work should be expanded and supported and it should be allowed to advertise its services more vigorously.

23. It may further encourage innovation and its exploitation if employees were more frequently able to share in the benefits of invention. In Germany such agreements are very common with fixed shares according to the profit made. In Britain a few research organisations do have employee agreements eg in BBSRC. These should be encouraged.

### The Provision of Finance to Support Enterprises Involved in the Application of Research and Innovation

24. As numerous reports have pointed out the crucial stage for the application of research and innovation is the "demonstrator" stage where large sums are often required but a high risk is attached. It is at this stage that "patient money" is required. In some engineering and physical science areas the sums needed may be so large and long term that government underpinning will be required. It is also at this "bridging" stage between innovation and its application that PSREs and RTOs play an important role in holding the process together.

### The Role of the Foresight Programme in Fostering Networks and Identifying Priorities

25. Although the Foresight process has generally been regarded as successful in fostering networking there are doubts about its effectiveness in follow through and monitoring. The Foresight Steering Group itself identified several areas where government and its agencies needed to take a lead. For example, it recommended developing long term sources of funding to take forward projects; it advocated using government procurement to stimulate technology; a strengthening of OST's coordinating function across departments by developing systems of oversight to track progress in shifting portfolios of research and by using the Forward Look as a proactive strategic planning exercise; and the need to develop a coordinated response on training and regulatory issues. In defence technology it suggested "demonstrators" should be included when joint DTI, OST, civil industry and defence priorities are being considered; research councils should be represented on Technology Foresight Panels; and the Council for Science and Technology should examine anything needed to strengthen Britain's research infrastructure.

26. Even at the networking level, however, there are fears that although existing networks have been reinforced new ones, particularly between universities and industry including many SMEs have been patchy. One of the problems which still needs to be tackled is how to involve SMEs many of whom do not have the infrastructure or staff resources to participate in Foresight activities.

27. We welcome the strengthening of the coordination of Foresight at the strategic level by the expansion of the Steering Group in include the CBI and TUC. These processes need to be inclusive of all stakeholders including employees both at the centre and at every level in the process. We also welcome the formation of a Ministerial Foresight Group to coordinate Foresight across Whitehall. We particularly welcome the statement by the Deputy Prime Minister that DETR will be closely involved with the Construction, Transport and Natural Resources and Environment Foresight Panels. We hope that the scientific resources which have been in decline, particularly in Transport (see para 13) will be boosted to ensure the right level of support is given to the work of these panels at every stage.

28. It is to be hoped that Ministers will also generally strengthen the role of OST in securing interdepartmental coordination and a strong cross departmental voice in the PES round as the Committee recommended last time. Otherwise, being only a small voice in each department, the overall expenditure on science is likely to be further squeezed. It is also worrying that the Cabinet Minister for Science has stated publicly that she has no power over other departmental ministers in that regard.

### The Role of the Engineering and Physical Sciences Research Council in Fostering Technology Transfer

29. We welcome the action of the EPSRC in going ahead with setting up four Faraday Centres, despite the last minute withdrawal of the DTI and its promised £3 million funding. We are particularly pleased to see that one of the winning four initial Faraday Centres or partnerships—concerned with Intelligent Sensors for Control Technologies—includes the National Physical Laboratory.

30. The objective of the Faraday programme as originally spelt out by CEST in 1992 (The Faraday Programme Working Paper 1 by Dr R C Whelan) was to provide an active technology development process involving the flow of industrial technology and skilled people. Indeed, Faraday Centres explicitly recognised

the vital role of people in the technology transfer process and that "communicaiton takes place through flows of people with the right balance of skills and experience". Faraday Centres can provide the infrastructure for groups of people or institutions—researchers and SMEs who cannot provide it themselves—to enable them to attract government, industry and EU funding. It is important that the DTI provide the promised funding for these important prototypes, and for others which hopefully will follow.

PEOPLE

31. As far as people are concerned the general description of the situation in the Committee's previous report has not changed much. Indeed, in some respects it is worsening. Supply and demand for scientists is in a "low level equilibrium"—a slowly sinking balance of weakening "effective" demand and remorselessly weakening supply. We are constantly told that the future of the economy depends on the knowledge of our citizens and scientific knowledge in particular has a crucial part to play. However the numbers of scientists employed as such is declining, not only in the public sector where numbers have declined dramatically with cuts in funding, privatisation, contractorisation and radical reorganisation, but also in the private sector (see Tables 4 and 5).

32. Career prospects and pay are also poor by comparison with alternative professions. In particular there is the continuing scandal of short term contracts as the normal method of employment for new recruits in university research and research councils, and the practice is increasing elsewhere in the public sector. Not only is this form of employment unacceptable for staff who in most cases, with the notable exception of Leeds and Heriott-Watt and some "new" universities, have to "waive" unfair dismissal and redundancy rights. It is also seriously reducing the knowledge base of research establishments, as STAs pass quickly through taking their knowledge out with them. We support the Concordat and are taking part in consultations on its implementation within Research Councils and Government. It is also vital that legislative action is taken to remove the use of "waiver clauses".

33. The poor career prospects for scientists are feeding back into student numbers. Work done by the Science Alliance (composed of IPMS, AUT, MSF and NATFHE) and published in "Contract or Career" March 1996 showed that although the UK was top of the international league in producing science graduates per thousand in the labour force it was bottom of the league in the percentage of 35–54 year old workers employed as professionals in physical and engineering, science, life science and associated sectors. It showed that one third of all science graduates moved out of science all together at graduation, one third went into science related jobs, and one third continued in science education/research. Of those who became science post graduates only one third would eventually achieve a career in science.

34. There is also concern, as we noted in our recent evidence to the Committee on the impact of Dearing, that Government decisions on student fees will impact particularly adversely on science and engineering students who will be penalised for choosing more expensive and longer courses.

35. It is no bad thing that scientifically trained staff are moving into areas of work outside "core" science, such as the city and it would be useful to know if they are having any impact on attitudes to science funding there. However, there are very few detailed statistics on what is actually happening in the scientific labour market. There has also been a laissez-faire attitude to redeployment of those made redundant from areas such as defence, nuclear energy, and other energy areas, where there has been a huge wastage of valuable talent. Similarly, until recently there was very little attempt to follow what happens to STAs when they leave. We understand that the OST has commissioned a study of career paths which may remedy some of this deficit. But it is important to establish much better continuous intelligence about what is happening in the science labour market. Such statistics should include gender, non graduate as well as graduate staff, and different patterns of working (eg short term contracts and part-time working). This is also an area which the Science Technology and Mathematics Council has begun actively exploring.

36. Within the IPMS areas of employment following termination of the national civil service pay agreements in 1995 statistics on pay and grading which are meaningful across departments, agencies and research councils are no longer available. Nor can the civil service any longer identify the pay, grading and career paths of individual specialisms, since all are now in diverse unified grading systems within each department or agency. This is a major statistical deficiency which must be remedied otherwise we have no way of knowing how scientists overall or women in science are developing even within the government's own staffing domain.

37. We do know, however, that the haemorrhaging of scientists from government through privatisation, staff cuts and fragmentation into agencies has left the scientific civil service weak, demoralised and with fewer career prospects.

38. In the absence of officially provided figures IPMS has done its own survey of science pay, grading and career pathways in the civil service. This showed that budget and staff cuts and new devolved integrated pay and grading structures were a major constraint on career progression. Short term contracts were also a major constraint for those who were on them. Among other constraints mentioned by respondents were:

— no career routes for specialists;

— amount of time spent on contract/commissioned work;

— use of short term contract staff instead of developing skills internally; and

— pressure of work discourages use of release for training and development.

39. The survey showed that political pressure for greater emphasis on training has not yet resulted in an increase in training or a greater willingness or ability by employers to increase the resources available for training staff. The evidence from our survey is that spending has reduced in many more places than it has increased. Fewer respondents believe that promotion, career development and pay progression have improved over the last year than over the last five years and over half the respondents believed that prospects were continuing to worsen.

40. As can be seen from Table 6 support staff in science and technology have reduced to an even greater extent than graduate scientists and engineers. In the Autumn of 1997 the Royal Society in consultation with a range of organisations involved in science initiated a study of technical support in the modern laboratory. IPMS also surveyed its science branches as a contribution to that study and found:

— lack of career and pay progression for technical and support staff;

— a two tier approach both to access to training and career progression, which works against the interests of support staff;

— under utilisation of skills; and

— problems caused by short term contracts.

41. A consultative conference held by the Royal Society on emerging findings revealed that there were deep worries among senior university personnel that the increasing use of short term contracts and postgraduate research assistants in support roles was undermining the cadre of experienced technical staff required to provide long term competent support and many favoured greater use of systematic training schemes such as the modern apprenticeship scheme for technicians—a view which IPMS would support.

42. The evidence impressionistic and anecdotal though much of it is, supports the view that training and continuing professional development are a growing need among SET staff which currently is not being adequately met. The Science Technology and Mathematics Council is aware that there are some very good programmes where the occupational specialism and territory is well defined eg in the Chemical Industries, Medicine, and more recently in the Forensic Science area where a new Forensic Science Professional Development and Training Scheme has just been agreed. In other areas, however, continuing professional development beyond graduate and postgraduate level is only in its infancy.

43. In the innovation context, the Department for Education and Employment commissioned the ST&M Council and the National Council of Industrial Training Organisations (NCITO) to raise awareness among national training organisations, occupational standards councils and industry lead bodies of the technology Foresight Programme and its implications for training and education and to develop action plans. An initial paper was produced in December 1995—"Technology Foresight: the nurturing of the UK Skills Base" by Ben Martin of SPRU. It pointed out that the education and training infrastructure was the first of the five categories of generic infrastructural priorities identified in the Technology Foresight Programme. The Foresight Steering Group also gave top priority to training the trainers, particularly in the fundamentals of mathematics and physics. The paper set out the requirements identified both by the Foresight Steering Group and the Panels which will need to be followed up in detail by training organisations and employers.

44. If the UK is to be innovative and competitive and it is acknowledged that people are the key resource then the short term contract approach of buying in ready made specialist expertise and then dismissing it when no longer required for a specific project or when someone cheaper or with "newer blood" comes along is unsustainable. We need a much more serious, sustained, and genuine investment in people. We need a much more strategic approach to identifying and boosting "effective" demand for science and technology staff and to ensuring a well trained supply to meet it.

*11 March 1998*

## TABLES

### Table 1

DECLINE IN GOVERNMENT R&D FUNDING (REAL TERMS 1985–6 TO 1998–9)

*£ million base year 1994–5*

| | *Outturn* | | *Plans* | *% Change* | *% Change* |
|---|---|---|---|---|---|
| | *1986–7* | *1995–6* | *1997–8* | *86–7/95–6* | *86–7/97–8* |
| OST[1] & Research Councils | 875.4 | 1,239.5 | 1,223.0 | | |
| HEFC | 1,112.8 | 1,017.7 | 981.0 | | |
| Total Science Vote | 1,988.2 | 2,257.2 | 2,204.0 | +13.5 | +10.9 |
| Civil Departments | 1,612.6 | 968.8[2] | 876.0[2] | −39.9 | −45.7 |
| Defence | 2,975.4 | 2,106.9 | 2,040.0 | −29.2 | −31.4 |

| | *£ million base year 1994–5* | | | | |
|---|---|---|---|---|---|
| | *Outturn* | | *Plans* | *% Change* | *% Change* |
| | *1986–7* | *1995–6* | *1997–8* | *86–7/95–6* | *86–7/97–8* |
| Total Departments | 4,588.0 | 3,075.7 | 2,916.0 | −33.0 | −36.4 |
| Indicative contribution to EU | 147.3 | 334.9 | 349.0 | | |
| Grand Total Real Terms[2] | 6,723.5 | 5,667.8 | 5,469 | −15.7 | −18.7 |
| Grand Total Cash Terms[2/3] | 4,350.1 | 5,667.8 | 5,718 | +30.3 | +31.4 |

*Source:* 1997 SET Statistics Tables 3.1 and 3.2.

NOTE:

1. OST forms a very small percentage £25.4 million in 1995–6, equivalent to just over 1 per cent of the Science Vote.
2. Excludes NHS, which is included in DH R&D return from 1995–6.
3. Cash terms taken from table 3.1.

**Table 2**

BUSINESS ENTERPRISE R&D (AS A PERCENTAGE OF GDP)

| *Year* | *UK* | *Germany*[1] | *France*[2] | *Japan*[3] | *USA*[4] |
|---|---|---|---|---|---|
| 1988 | 1.47 | 2.07 | 1.35 | 1.93 | 2.00 |
| 1989 | 1.49 | 2.07 | 1.41 | 2.06 | 1.96 |
| 1990 | 1.51 | 1.98 | 1.46 | 2.15 | 2.00 |
| 1991 | 1.42 | 1.81 | 1.48 | 2.12 | 2.07 |
| 1992 | 1.42 | 1.70 | 1.51 | 2.03 | 2.01 |
| 1993 | 1.44 | 1.62 | 1.51 | 1.90 | 1.88 |
| 1994 | 1.38 | 1.54 | 1.47 | 1.87 | 1.80 |
| 1995 | 1.34 | 1.51 | 1.44 | 1.95[p] | 1.85[p] |

*Source:* Office for National Statistics.

NOTES:

1. There are breaks in series between 1990 and 1991, and 1991 and 1992.
2. There is a break in series between 1991 and 1992.
3. Data from Japan are adjusted by OECD.
4. Excludes most or all capital expenditure. There is a break in series between 1990 and 1991.

p. Provisional.

**Table 3**

COMPARING UK R&D/SALES RATIOS WITH G7 AVERAGES USING NATIONAL ACCOUNTS STATISTICS

| *Sector* | *Contribution to GDP (%)* | *Gross Output £m* | *R&D expenditure* | *R&D intensity* | *G7 average intensity* |
|---|---|---|---|---|---|
| **High tech:** | | | | | |
| Pharmaceutical | 0.8 | 9,296 | 1,789 | 19.2 | 11.2 |
| Aerospace | 0.8 | 9,952 | 880 | 8.8 | 12.8 |
| **Medium tech:** | | | | | |
| Electrical machinery | 2.0 | 35,085 | 1,232 | 3.5 | 6.9 |
| Chemicals | 1.6 | 31,933 | 803 | 2.5 | 3.4 |
| Transport equipment | 1.6 | 35,294 | 689 | 2.0 | 3.1 |
| **Low tech:** | | | | | |
| Mechanical engineering | 3.3 | 48,701 | 756 | 1.6 | 3.8 |
| Other manufacturing | 11.6 | 189,476 | 782 | 0.4 | 0.8 |
| **Total manufacturing** | 21.5 | 359,738 | 6,931 | 1.9 | 2.5 |

*Sources:* ONS, OECD, DSTI.

NOTES:

1. G7 excludes Italy in Pharmaceuticals and Aerospace sectors due to unavailability of data.
2. UK data refers to 1994, G7 data to 1992.

Quoted from UK R&D Scoreboard 1997, DTI.

**Table 4**

TOTAL PERSONNEL ENGAGED ON R&D IN THE UK 1986–1995

| *000s FTE* | *1986* | *1995* | *% Change* |
|---|---|---|---|
| Business | 188 | 148 | -21.3 |
| Research Councils | 14 | 12 | -14.3 |
| Govt Depts | 24 | 17 | -29.2 |
| HEIs | 52 | n/a | n/a |
| Private Non-Profit | 7 | 5 | -28.6 |
| TOTAL | 285 | 182 | -36.1 |

*Source:* 1997 SET Statistics Table 8.3.

Within Government the MOD has suffered the largest loss of R&D personnel, as shown in Table 5.

**Table 5**

27 TOTAL PERSONNEL ENGAGED ON R&D WITHIN GOVERNMENT

| *000s FTE* | *1986-7* | *Estimated Outturn 1996-7* | *Plan 1997-8* | *% Change 86-7/96-7* | *86-7/97-8* |
|---|---|---|---|---|---|
| Research Councils | 13,857 | 11,506 | 11,360 | –17.0 | –18.0 |
| Civil Depts | 8,133 | 7,252 | 6,273 | –10.8 | –22.9 |
| MOD | 16,331 | 7,702 | 7,702 | –52.8 | –52.8 |
| TOTAL | 38,321 | 26,460 | 25,336 | –31.0 | –33.9 |

*Source:* 1997 SET Statistics Table 8.4.

**Table 6**

EMPLOYMENT[1] ON R&D PERFORMED WITHIN UK BUSINESSES: 1989 TO 1996

| | | *1989* | *1990* | *1991* | *1992* | *1993* | *1994* | *1995* | *1996* |
|---|---|---|---|---|---|---|---|---|---|
| Scientists and engineers | DLEJ | 85 | 83 | 80 | 82 | 86 | 83 | 83 | 80 |
| Technicians, laboratory assistants and draughtsmen | DLEK | 46 | 43 | 38 | 38 | 40 | 40 | 33 | 32 |
| Administrative, clerical industrial and other staff | DLEL | 45 | 45 | 41 | 39 | 37 | 34 | 30 | 26 |
| As percentage of total employment | | | | | | | | | |
| Scientists and engineers | DLEM | 48 | 48 | 50 | 51 | 52 | 53 | 57 | 58 |
| Technicians, laboratory assistants and draughtsmen | DLEN | 26 | 25 | 24 | 24 | 24 | 25 | 23 | 23 |
| Administrative, clerical industrial and other staff | DLEO | 26 | 27 | 26 | 25 | 23 | 22 | 20 | 19 |
| TOTAL | DLEI | 176 | 171 | 159 | 159 | 164 | 157 | 146 | 139 |

*Source:* Office for National Statistics.

NOTE:

[1] Full time equivalents in thousands.

## APPENDIX 44

### Memorandum submitted by Lucas Aerospace

INTRODUCTION

Lucas Aerospace is a Division of Lucas Varity plc. Lucas Aerospace is a global business with a major proportion of its manufacturing being based in the UK. Lucas Aerospace is a leading supplier of safety critical equipment to the Aerospace Industry. Having leading technology is key to its continuing growth and success. Retaining leading technology requires Lucas Aerospace to make significant investments in technology acquisition and have close relationships with the research base.

SUMMARY

Technology is extremely important to the competitiveness of Lucas Aerospace and Lucas therefore has close links with Universities to identify innovations which may benefit its product portfolio. It considers relationships with Government laboratories and independent research organisations extremely important in achieving technology transfer. Collaboration in technology acquisition is important for affordable technology to develop its Aerospace Supply Chain. Ownership of intellectual property rights is key to protecting the technology investment and protecting our competitive position.

Government sponsorship of research and demonstration permits Lucas Aerospace to invest 30 per cent more than would otherwise be affordable on technology acquisition. Lucas Aerospace welcomes the Foresight initiative in developing networks and priorities at a general level but are disappointed at the Government lack of support for the Society of British Aerospace Companies response to the Foresight initiative—Foresight Action. Lucas Aerospace consider that a larger proportion of the Engineering and Physical Sciences Research Council sponsored research should be directed to industrially supported activities.

1. Lucas Aerospace is a "market pull" driven Company. The decision to pursue new technology is linked to a marketing assessment of the benefit of new technologies to future business opportunities. This applies whether these future opportunities are protecting existing markets and products, expanding these markets or penetrating new markets. A fundamental element of this process is maintaining close links with the full

breadth of the research base, particularly in the UK and Europe to identify innovations applicable to our product portfolio.

2. The majority of the fundamental research adopted by Lucas Aerospace for application to products is originally conceived through Government funded research in Universities and government Laboratories. This fundamental innovation is then used in an applied research programme, usually carried out by Lucas Aerospace in collaboration with the innovating research house, to gain sufficient knowledge and understanding of the fundamental technology to apply it to our products. This is key to achieving the necessary technology transfer which is dependent on knowledge and people.

3. Lucas Aerospace have extensive links with both Government Laboratories and independent research and technology organisations. These links include joint technology programmes. These links include, but are not limited to, National Physical Laboratory (NPL), Atomic Energy Authority (AEA Tech) and the Defence Evaluation Research Agency (DERA).

4. Lucas Aerospace make extensive use of Government schemes to promote collaboration. These include the DTI initiative "Civil Aircraft Research and Demonstration—CARAD" and the Engineering and Physical Science initiatives—Innovative Manufacturing Initiative (IMI) and Link. These initiatives, through modest levels of sponsorship, promote collaboration in an effective way and give companies opportunities to use such collaborative research to develop the overall business supply chain with both customers and suppliers as well as gaining technology.

5. Lucas Aerospace considers it extremely important, wherever possible, to own the intellectual property rights (IPR) and patents relating to the technology in its products. This ensures security of product delivery and retention of competitive advantage. Where the IPR is owned by another organisation, Lucas Aerospace would try to achieve either an exclusive licence or at least exclusivity in the application in its field of business.

6. The Foresight Programme has played a significant role in fostering and developing networks. In the Aerospace industry the Society of British Aerospace Companies response to the Foresight Programme—"Foresight Action" has developed an Aerospace network of major potential benefit—It is disappointing that Government have not been able to respond in a significantly more positive manner to "Foresight Action" with matching funding.

The Foresight Programme has identified priorities at a global level, in particular industrial arenas. It must, however, be recognised that any individual company will not necessarily see the Foresight priorities matching their priorities. It is felt that if these priorities are used as a guide to directing innovative research they should result in a research base of benefit to industrial needs.

7. The Engineering and Physical Sciences Research Council have introduced, over the years, various initiatives to foster technology transfer (some of these were mentioned in 4 above). It is considered that these initiatives should be extended to ensure that the majority of sponsored research is supported and directed by industry. This would ensure that this applied research does serve the needs of the UK Aerospace industry and that the link with industry acts as the technology transfer bridge.

*26 February 1998*

## APPENDIX 45

### Memorandum submitted by the Machine Tool Technologies Association

1. The Machine Tool Technologies Association (MTTA) is the leading organisation in the UK representing the interests of manufacturers, importers and distributors of machine tools and ancillary equipment.

2. As such, the machine tool sector is ideally placed, at the leading edge of technology—due to its close relationships with suppliers, customers and academia—to contribute to and take advantage of opportunities for joint funded research into potentially commercial applications.

3. It is vital that research activities are industry-led and involve a balanced partnership of organisations including major customers, eg automotive and aerospace, SMEs, research and technology organisations, universities and trade associations. Such combinations will often be based on existing supply chains.

4. A key role of Government should be "enabling/matching", ie helping to bring together technology suppliers (universities and research and technology organisations) with industrial users, possibly using the Internet as a source of information. This is especially relevant for smaller companies who, generally, have little knowledge of sector funding, how EPSRC operates and the availability of support for research and product development. Conversely, academia's understanding of the needs of the private sector needs to be expanded in order that universities and research and technology organisations develop programmes that the private sector can apply commercially. Again, the Internet could be used as a source of information as to what is available.

5. It is generally considered that the gradual reduction of Government-funded research has, naturally, resulted in a decline in industrial applications of such research. There is, however, an increase in collaborative

research activity in Europe, funded by the EC, eg BRITE–EURAM and ESPRIT which open up opportunities for UK Industry and Academia.

6. Government schemes designed to promote collaboration in and industrial application of research tend to be very bureaucratic and complex to initiate. Consequently, smaller companies are reluctant to participate.

7. Following conclusion of research projects, further support is often necessary to commercialise the results and bring products to market. Finance could be available from Government, venture capitalists and other financial institutions but is often limited to projects with minimal risk. Mechanisms need to be created which will support companies to bring innovative products to market, possibly including pay-back clauses to investors, private and public, when resulting profits are realised.

8. Intellectual property rights and the results of research are often treated with too much importance, prior to a project commencing. Companies are sensitive to their IPR being disclosed as are the universities. However, in a competitive economy, the major benefit of developing innovative products is to launch them in the market first and gain a time advantage on the competition.

9. The role of the Foresight Programmes requires "tailoring" to the requirements of specific industry sectors with trade associations being used to translate foresighting information to their members and, conversely, being the medium through which the Foresighting panels can understand the sector's requirements and aspirations.

*6 March 1998*

## APPENDIX 46

**Memorandum submitted by Professor Ben Martin, Science and Technology Policy Research (SPRU)**

### THE ROLE OF FORESIGHT IN FOSTERING NETWORKS[1]

Recent work on the relationship between technological development, innovation and economic performance has focused on the concept of the "national innovation system". In this, the emphasis is not just on the constituent actors within that system—firms, universities, government research laboratories and so on—but more importantly on the relationships and linkages between them. The notion of a national innovation system was first described by Professor Freeman (from SPRU) in relation to Japan; he defined it as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies[2].The concept has since been developed by others and fleshed out with various empirical studies[3]. (A useful summary of the concept and these empirical studies can be found in a recent OECD report[4].)

The concept of the national innovation system has come to prominence for several reasons. One is the growing economic importance of knowledge, with many economic activities becoming increasingly knowledge-intensive. A second and closely related reason is the widening range of institutions involved in knowledge generation[5]. Another reason is the emerging interest in systems approaches to the study of technological development, not least because of widely recognised limitations of the traditional linear model of innovation[6].

As the foresight exercise in the UK (and indeed foresight activities more globally) have all demonstrated, many important potential innovations and the emerging generic technologies likely to underpin them are characterised by the confluence of a number of component technologies[7]. This creates the need for multi-disciplinary, multi-institutional and even, in a number of cases, multinational effort, and hence for networks, co-operation and partnerships. The development of such networks is becoming more crucial.

At the heart of the concept of the national innovation system is a belief that a better understanding of the linkages between the component actors in the system is the key to improved technological performance:

> The national innovation systems approach stresses that the flows of technology and information among people, enterprises and institutions are key to the innovative process. Innovation and technology development are the result of a complex set of relationships among actors in the system. For policy-makers, an understanding of the national innovation system can help identify leverage points for enhancing innovative performance and overall competitiveness. Policies which seek to improve networking among actors and institutions in the system are most valuable in this context[8]. (original emphasis)

The policy implications of the national innovation system concept are far-reaching. As OECD has argued, it suggests a new rationale for government funding of research and technology based on correcting systemic failures—in other words, the lack of effective interactions between the actors in the system. It also points to the need for new types of policies to address those systemic failures, policies that develop, extend and strengthen the communication and the flows of information, and the networking, co-operation and linkages between the component organisations that make up the national innovation system[9].

On the basis of experiences with the Foresight Programme in the UK and similar activities in other countries (eg Germany, Japan, the Netherlands, Australia), foresight would seem to offer a fruitful

mechanism for pursuing such policies. In particular, the process benefits have proved substantial[10]. These process benefits are captured in "the five C's"[11]:

- foresight has enhanced Communication (among companies and among researchers, and between researchers, users and funders);
- it has resulted in greater Concentration on the longer–term future;
- it has provided a means of Co-ordination (again among researchers, and between researchers, users and funders);
- it has helped create a level of Consensus on desirable futures over the next 10–20 years;
- it has generated Commitment to turning the ideas emerging from the foresight programme into action.

These five C's correspond to areas where the UK was previously perhaps rather weak in comparison with countries such as France, Germany and Japan. Foresight provides a mechanism for developing strategies without engaging in top-down planning.

These process benefits associated with foresight are very much concerned with fostering productive long-term partnerships and networks—among researchers and among firms, across industrial sectors, and between industry, universities, government and society at large. Thus, foresight offers a means of "wiring-up" and strengthening the connections within the national innovation system so that knowledge can flow more freely among the constituent actors, and the system as a whole can become more effective at learning and innovating.

The above arguments are also related to notions of organisational learning (within an organisation) and system-wide learning (in this case, in the national innovation system). Such learning requires a process for stimulating, nurturing, encouraging and strengthening interactions between the actors so that the linkages between them become more permanent. In the case of system-wide learning, we need a process capable of wiring up the national innovation system so that it too becomes more effective at learning. The more this wiring up takes place, the more effective the national innovation system should become in terms of learning and hence innovating. Foresight is a process for achieving this goal.

Mathews has made a similar point in relation to "high technology" industrialisation in East Asia, arguing that such industrialisation depends on the level of interdependence between the players involved. "The more sophisticated this network of institutions, the faster the economic learning, and the more secure the process of high technology industrialisation"[12]. From this, he develops the concept of the "national system of economic learning". Whereas organisational learning is concerned with each organisation learning individually, economic learning involves learning in the wider industrial system comprising the interactions between firms, the market and the state more generally.

Technology foresight offers a means to facilitate such economic learning. With this should come an increase in the "knowledge distribution power" of the national innovation system[13] and hence in its capacity for innovating. Effective knowledge-distribution and learning are becoming ever more important as we move towards the knowledge-based economy. To strengthen the national innovation system, we need to stimulate, extend and deepen those interactions if the system is to learn and innovate more effectively. The Foresight Programme is providing a fruitful mechanism to help achieve this.

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11 See Irvine and Martin, op cit note 7, p 144; and B R Martin and J Irvine: *Research Foresight: Priority–Setting in Science,* Pinter Publishers, London and New York, 1989.

12 J A Mathews, High Technology Industrialisation in East Asia, *Journal of Industry Studies 3,* 1–77 (1996) see p 64.

13 P David and D Foray, Assessing and Expanding the Science and Technology Knowledge Base, *Science, Technology, Industry Review 16,* 13–68 (1995). See also P den Hartog et al: *Assessing the Distributional Power of National Innovation Systems: Pilot Study of the Netherlands,* TNO Centre for Technology and Policy Studies, Apeldoorn, 1995; and S Numminen, *National Innovation Systems: Pilot Case Study of the Knowledge Distribution Power of Finland,* VTT Group for Technology Studies, Helsinki, Finland.

## APPENDIX 47

### Memorandum submitted by the Medical Research Council (MRC)

Answers to the questions raised in the Clerk's letter of 1 June are set out below. We have also added a note on the anticipated benefits of the UK Medical Ventures Fund to the MRC. There are two key points which the committee might wish to bear in mind in considering how far the MRC experience might be applicable in other sectors.

> The industrial sectors which draw on MRC-funded research are comprised of highly innovative and R&D-intensive multinational pharmaceutical companies and "high tech" SMEs—we knock on a relatively easily opened door.
>
> Like other research councils, we have no direct control or responsibility for exploitation of the IP/IPR generated by grants to universities. The process of raising capital for UK Medical Ventures Fund, and the intellectual seeds of its future business, derive entirely from the track record of high-quality research in the 40 research institutes/units where IP/IPR is owned and managed by the MRC through its in-house Technology Transfer Group.

### UK MEDICAL VENTURES FUND
### UK MEDICAL VENTURES MANAGEMENT LIMITED

1. How the New Fund Works?

(a) *Legal Structure*

The fund, UK Medical Ventures Fund is a 10 year limited partnership under English law. The investors into the fund are the Limited Partners.

The General Partner, ie the management of the limited partnership, is contracted to UK Medical Ventures Management Ltd (UKMVML), a wholly-owned subsidiary of the Medical Research Council. UKMVML is subject to regulatory control by the Investment Management Regulatory Organisation (IMRO).

UKMVML has appointed a Board of Directors comprising three experienced (in finance, biotechnology and pharmaceutical industry) independent directors, one representative of the Limited Partners, the CEO of UKMVML and three representatives of the MRC.

A legally binding agreement between the Fund and the MRC obliges the MRC to work through the Fund when Council chooses to exploit technology it owns and/or controls through "spin–out" company formation. The fund is obliged to invest not less than 75 per cent of its money in companies formed to exploit technology originating in MRC Institutes and Units.

UKMVML is managed by its Chief Executive Officer, Dr Stephen Reeders. Dr Reeders has a proven "track record" in both molecular genetics research, and more recently in a biotechnology investment position in New York. Dr Reeders has recruited two further Investment Managers.

(b) *Operational processes*

The Committee should understand that UK Medical Ventures Fund is a recent initiative, and working practices are expected to evolve further. The anticipated approach is that the MRC Head Office Technology Transfer Group staff take the lead working with MRC Institute/Unit researcher scientists to identify technology for potential "spin-out" companies. Each opportunity will be made known to UKMVML, which has a six-month exclusive period for development of a satisfactory Business Plan suitable to be financed by

UKMVML. UKMVML may choose to involve a second investment fund, but anticipates "leading" investments. If necessary, UKMVML Fund Managers will provide interim management to its portfolio companies. The preparation of the Business Plan includes negotiation between the MRC Technology Transfer Group and UKMVML on the value attributed to the technology, and hence the share holding to the MRC.

It must be anticipated that UKMVML:

(1) concur with the MRC/TTG assessment of the "spin-out" company opportunity, develop a satisfactory Business Plan, with agreement on the value to be attached to the technology. In this circumstance, the investment can be completed and a start made to implement the "spin-out" company Business Plan;

(2) reject the potential investment opportunity as unsuited to company formation. In such circumstances, the MRC is free to exploit the technology through alternative mechanisms;

(3) agree that the technology provides the basis for a "spin-out" company but that TTG and UKMVML are unable to agree the value of the technology. In such circumstances, the MRC becomes free to seek alternative investment, but is precluded from accepting a materially lesser investment from a third party. In addition, UKMVML is free to improve on alternative offers from other parties.

## 2. What Level of Funding?

UK Medical Ventures Fund has closed at its maximum funding—£40 million, from eight Limited Partners.

The MRC has made no investment into the fund, beyond the commitment of administrative staff time, to cover certain "out-of-pocket" expenses and the temporary provision of office space, during the formation of the fund. These costs were reclaimed from UK MVML, once money was raised.

## 3. MRC's Reasons for Establishing the Fund?

The MRC has a long-standing commitment to exploitation, including "biotech" company formation. Celltech plc, usually considered to be Europe's first biotechnology company was formed specifically to exploit technology from the MRC Laboratory of Molecular Biology. Since that time, a growing number of MRC "spin-out" companies have been formed including Cambridge Antibody Technology plc, Therexsys Ltd, (recently renamed Cobra Therapeutics Ltd), Prolifix Ltd, RiboTargets plc and Cambridge Genetics Ltd. The creation of these companies was, without exception, a protracted, and in our view, inefficient process confirming the widely recognised difficulty to access the first investment round into "spin-out" companies. The primary reason to establish the fund was to enhance the access to see/venture investment for MRC "spin-out" companies.

## 4. Benefits to the MRC

The creation of UK Medical Ventures Fund is intended to facilitate the MRC objective to participate in "biotech" company formation whenever practical. The Fund provides access to £40 million for company formation, of which at least £30 million must be invested in biotech companies exploiting technology originating within MRC Institutes and Units. In addition, the Fund management structure provides for three highly competent investment managers to be focussed primarily on fostering "spin-out" company formation based on MRC technology.

The MRC will also benefit directly from the financial success of UK Medical Ventures Fund. In addition to a share holding in each "spin-out" company reflecting the value of each specific technology, the Fund structure includes an incentive to the General Partner through the carried interest principle; the greater the returns to the Limited Partners, the greater the rewards to General Partner. The General Partner, UK Medical Ventures Management Ltd, a wholly owned subsidiary of the MRC, will use the carried interest in part as incentive to its investment management team, and partly as a return to Council. In addition to the conventional participation in the carried interest, the MRC will receive a further benefit in the form of an additional five per cent carried interest, in recognition of the privileged position of UK Medical Ventures Fund to technology from MRC Institutes and Units.

*29 June 1998*

## APPENDIX 48

### Memorandum submitted by NatWest Group, Innovation and Growth Unit

1. Introduction

This memorandum has been prepared by the NatWest, Innovation and Growth Unit, drawing mainly on extensive experience in the technology-based business sector over a number of years (the Innovation and Growth Unit was established in 1989). Limited consultation has been undertaken with other Units within the Bank.

2. Summary

The Committee are conducting an inquiry into Innovation and Technology Transfer in the fields of engineering and physical sciences. Specific terms of reference have been agreed and this submission covers those areas where we consider ourselves able to offer comment.

- it is essential to create a supportive environment, both economic, fiscal and social where innovation and new product development are actively encouraged;
- academia needs to be encouraged to consider the commercial applications of research and supported in their efforts to exploit the opportunities. This will require a cultural change in academia towards the USA model of commercial exploitation from academic institutions;
- the Government has an important role to play at all levels—maintaining stable economic conditions, encouraging new innovations through fiscal incentives (eg R&D write off against future profits, encouragement of informal investment), direct support to innovative enterprises via targeted Grants and Awards and the continued encouragement of "support organisations" to provide coherent "one–stop" support services that are easily understood by SMEs;
- the understanding of the innovation process in its various forms by all relevant parties (Government, Financiers, Academia and Support Organisations) is essential in order to provide a range of solutions to the range of circumstances;
- the identification, understanding and protection of Intellectual Property Rights is vital to the creation of wealth in the technology-based business sector. The early involvement of experts in this area by businesses and the development of accepted methodologies for the valuation of IPR should be encouraged;
- the funding programmes via the Engineering and Physical Sciences Research Council (EPSRC) could be linked to the Foresight Programme to focus research work;
- selectivity in research is essential. Resources will always be scarce and their distribution will require careful management to ensure that the best projects and best scientists and engineers are supported. It is essential that the capabilities of our world-class centres maintain their international standards. The crucial question is the level and degree of selectivity that is appropriate;
- to enhance the chance of success in these start-up businesses, the wider aspects of business management need to be addressed. Technology alone will not produce world leading businesses. The role of "business mentors" could be considered—ie the establishment of a register of experienced businessmen who would be willing to act as mentors.

3. Enclosures[29]

- "*Innovation Business*"—Issue 18;
- "*Innovation Business*"—Issue 19;
- CBI/NatWest Innovation Trends Survey 1997.

4. Scope of the Inquiry

"to inquire into the manner in which companies in the fields of engineering and physical sciences decide on developing new products and processes and the factors influencing their decisions, with particular reference to:

[29] *Not printed.*

4.1 *"the industrial application of Government-funded research"*

It is widely recognised that the ability of the UK commercial base, especially manufacturing industry, to innovate in the fields of new product, process and service development, is vital to the economic future of the UK. The process of innovation is complex and requires interaction between diverse networks to achieve successful results. Government funded research is only one of these networks.

In our opinion, industrial/commercial exploitation should not be the sole focus of Government funded research. Indeed, it would be inappropriate for publicly funded research in the Science Base to be driven by the short term requirements of industry. However, it is clear that there exists tremendous potential for UK industry to benefit, in terms of performance and competitiveness, from utilisation in the commercial world of technological advances made in the Science Base.

The level of collaborative activity between academia and industry has increased, but there remains significant scope for this activity to be extended further, particularly amongst the SME base. Increased activity in the areas of joint-ventures, "spin-outs" funded by Corporate venturing arrangements and commercial research projects would lead to improved product development and innovations. The recently announced University Challenge Fund is welcomed.

4.2 *"the respective roles of Government Laboratories and independent research and technology organisations"*

From our experience with SMEs, both are cost-effective and essential elements of the Science and Technology Base. Both sets of organisations provide valuable services in the innovation process with their ability to communicate with both academia and industry. They have demonstrated particular usefulness to physical science based businesses.

The range of organisations in this sector, particularly the independent Research and Technology Organisations, has meant that specific areas of expertise have developed and this offers significant advantages to SMEs.

The services offered by the range of organisations and the benefits of SMEs should be promoted through the network of support/advisory organisations eg Business Links.

4.3 *"the operation of Government schemes designed to promote collaboration in and industrial application of research"*

The encouragement of collaborative programmes between academia and industry is welcomed, but, from our experience it is difficult to draw general conclusions with regard to the effectiveness of these schemes.

The range of ESPRC schemes eg Faraday Partnerships, together with other schemes eg LINK, NEST, CARAD, ROPA, JREI, all contribute to increasing the awareness of collaboration as means of achieving success in innovation.

However, it is essential that the outcome of these schemes are monitored and measured to ensure cost-effectiveness.

From the perspective of extending utilisation of these collaborative schemes to a wider SME audience, it would appear sensible to consider reducing the number of schemes available, simplifying eligibility criteria and encourage support organisations to more actively promote the schemes to the SME community as a means of stimulating innovation and technology transfer.

4.4 *"intellectual property rights and patenting"*

The key issues are identification, appropriate protection and valuation of IPR. It is our experience that many organisations do not have a clear strategy in any of these key areas. A variety of different structures have been established from "do nothing" to very clear and effective strategies.

With the increasing importance of IPR this is a vital issue for UK companies and Higher Education Institutions. Valuable assets can be lost or sold/licensed too cheaply. Poorly constructed IPR protection strategies can be open to challenge and difficult to defend.

For effective collaborations, considerable time should be invested in clearly understanding IPR issues. A regular dialogue between industry and University Liaison Officers would promote an improved understanding of respective needs and co-operative working practices.

The issues surrounding Intellectual Property Rights are very complex and our experience suggests that expert advice and guidance is always the appropriate route to follow. Successful commercial exploitation of technology is inextricably bound with a valid, clearly thought-out and implemented IPR identification, protection and valuation strategy.

4.5 "*the provision of finance to support enterprises involved in the application of research and innovation*"

Previous Reports (*House of Commons Science & Technology Committee 1994, Bank of England Report 1996*) confirm that there is sufficient funding available for innovative SMEs, but that there are failures on both sides (entrepreneurs and financiers) in matching up the most appropriate funding for the business at its particular stage of growth. The main problems are:

- certain types of funding are misunderstood with regard to purpose and misapplied, eg overdrafts, which is primarily a tool for working capital, is frequently utilised to fund longer term capital projects or R&D activities. Within the NatWest lending portfolio the proportion of medium and long term loans is increasing, but there remains a short term mentality amongst SMEs;
- the level of management and financial expertise within SMEs is generally low. Our experience of innovative, mainly technology based businesses is that it may be even lower, founded as they often are by highly skilled technical personnel with limited management experience. This lack of experience and expertise in early stage SMEs is major factor in their high failure rates. This could be tackled by increased education and training of owners/managers or by increased management input from outside the enterprise.

In financing terms, the most important failure is in the provision of small-scale equity in the start up and early stages of growth.

- Members of the British Venture Capital Association invested £2.8 billion in 1,060 British companies in 1996 (£2.1 billion in 1995), but, of this sum only £38 million was invested in start ups and a further £93 million in early stage firms. The larger Venture Capital houses have moved away from "venture" towards development capital provision in the form of MBOs/MBIs, where returns are potentially greater, and the risk perceived as being far less;
- The reasons for this reluctance to invest in early stage technology based businesses can be traced to the "boom" of the mid to late 1980's when many technology based firms received investment and subsequently failed. This is acknowledged as being largely due to poor post investment support, and a misunderstanding of their needs, financial and management. In addition, the heavy costs of financial and non-financial due diligence combined with legal costs makes small deals uneconomic;
- There are a number of Venture Capital houses which specialise in funding early stage technology firms (eg MTI Managers, Prelude Technology, Top Technology). Their approach is to place great emphasis on post investment support at all levels of the business;
- There is also evidence to suggest that many Venture Capital providers are unable to properly assess the technology risk. This also applies to many traditional debt providers;
- There is a case to be made for the development of a defined and structured methodology for assessment of technology risk and financial risk for "bottom-end" investment (say £50,000 to £250,000), which could be delivered rapidly and at a cost effective price.

There are also other areas of support that could be introduced to ensure that maximum advantage is taken of innovative ideas:

- Training—innovators or entrepreneurs with commercially exploitable ideas need to be identified at an early stage and provided with practical and professional assistance in basic management techniques, financial and marketing functions. Improved early stage training is required, eg an "Innovation Handbook" could be developed. This initial training needs to be reinforced by the use of mentors on an on-going basis, to enable the business to cope with rapid market and industry change;
- Mentors—innovative, high growth orientated firms are more likely to succeed when led by multi-skilled management teams. Expert guidance at an early stage and on-going is vital. This expertise must be provided at a cost that the entrepreneur is able—and willing—to pay. This could either be cash or an equity stake. This could be achieved by:
  - a structured, nation-wide mentoring service;
  - the use of corporate mentors as well as individuals.

  The network needs to be professional and to rapidly establish credibility.
- Corporate Venturing—Business Angels are increasingly being perceived as a major source of investment and management skills. At present the role of Corporate Angels is relatively unresearched, but, from our experience can provide a vital role in the commercial exploitation of innovative ideas:
- Centres of Excellence—the development of more well-recognised and well-publicised Centres of Excellence in individual disciplines would assist in the promotion of greater understanding between financiers and the technology community.

There has traditionally been a reluctance by institutions to finance technology based SMEs. NatWest recognised this in the late 1980's and set up the Technology Unit, now Innovation and Growth Unit. This Unit has had considerable success in identifying and supporting technology based SMEs. The other main clearing banks are only now establishing their own versions following the sharply increased focus on this

sector over the past 12–18 months. NatWest's is the clear market leader in this sector reflecting our experience and reputation.

The reluctance by other banks to meet a clear market requirement is a result of a number of factors:

- unfamiliarity with the technology risk;
- fear of the perceived risk;
- misunderstanding of the financial and commercial requirements; and
- dynamics of innovative SMEs.

These factors all form part of what the Innovation and Growth Unit refer to as the Empathy Gap—a breakdown in actual and commercial understanding, and diversity in expectation of the two parties.

This gap can be bridged, and at NatWest we achieve this by:

- Technology Business Managers located throughout the network delivering rapid and practical support (these Managers have attended an intensive awareness course with regard to key issues affecting these types of business);
- a cost effective appraisal service that assesses technological risk and true potential of businesses;
- a dedicated technology and market information service for managers to assist them make well informed decisions;
- local and national networking to provide customers access to professional guidance/support;
- the ability to "scale up" the relationship—ie a flexible response to customers' changing needs throughout their start up and expansion phases;
- packaged funding which is truly appropriate to the needs of rapidly growing firms;
- a bank culture that is sympathetic to technology based and innovative enterprises based on true understanding, whilst retaining the ability to appraise risk effectively.

At the same time, companies themselves must try to understand more about the financiers' requirements:

- improving their financial and management skills and demonstrating their ability to plan, monitor and control the business;
- developing greater awareness of the range of finance available, and accepting that some propositions are not suitable for bank finance alone;
- considering long term loans or equity investment in preference to overdraft, even if it means losing 100 per cent control;
- improving long term planning, with more emphasis on marketing as the key to innovation success;
- greater appreciation of the benefits of strategic planning;
- working with their Technology Business Manager from an early stage in the business's development.

4.6 *"the role of the Foresight Programme in fostering networks and identifying priorities"*

The aim of Foresight is to secure sustained competitive advantage by:

- establishing visions of the future, and identifying priorities for action to assist the UK meet it's future needs;
- develop a culture of forward-thinking about market and technology opportunities and threats;
- creating enduring networks linking business, the science base, and government as a basis for generating action on the priorities identified.

The Foresight Programme's results are increasingly being used by businesses to assist them to make better investment decisions and reduce risk. Companies can identify new opportunities for innovation and threats to existing activities; become aware of the contribution science, engineering and technology can make to business success; identify sources of knowledge in the science base to improve competitiveness and develop the flexible management structures and creative; long-term strategies that will meet their future needs.

Foresight is fostering investment in new partnerships between business, the science base and government through the LINK programmes. It is estimated that around £400 million has been committed to initiatives reflecting Foresight priorities.

At the present time proposals are being sought for the next round of work under the UK Foresight Programme. The next round will commence in April 1999 and is aimed at creating a much broader basis of participation, including SMEs, Trade Associations, Professional Institutions, RTO's and other intermediaries.

The objectives of the next round are supported and welcomed. Extended participation in the process and use of the results can only be beneficial in fostering networks and lead to an increase in commercial exploitation of new technology.

4.7 *"the role of the Engineering and Physical Sciences Research Council (ESPRC) in fostering technology transfer"*

The ESPRC operates a number of schemes and Awards designed to initiate and improve technology transfer. Our direct experience of the success of these schemes is limited.

However, we are of the opinion that measurement of the outputs is essential to ensure cost effectiveness and that the emphasis of future awards should be closely allied with the identified priorities of the Foresight Programme.

4.8 *"progress made towards implementing those recommendations of the Science and Technology Committee in the previous Parliament in their report on The Routes Through Which the Science Base is Translated into Innovative and Competitive Technology*[30] relevant to the fields of engineering and physical sciences"

The broad range of recommendations of the previous report has provided a platform for policy development and this has been further stimulated by the heightened debate on and recognition of the innovative, technology based business sector as one of the main drivers of competitive advantage and growth in the UK. This sector and its successful commercial exploitation of innovative ideas is vital to the future international standing of the UK.

Our opinion is that the many strands of support and collaboration networks need to have a stronger cohesion and provide the SME with simpler access to guidance, advice, funding and potential collaborative partners.

In order to achieve this process we believe that the DTI, in liaison with the Foresight Programme and the various research Councils are in the best position to provide leadership and achieve the sharper focus that is required.

*12 May 1998*

**Letter to the Clerk of the Committee from Graeme Jones, Head of Innovation and Growth Unit, National Westminster Bank Plc**

I refer to your letter of 15 December and would like to add the following observations to supplement the evidence which we submitted to the Committee back in May of last year.

From our perspective there have been two main events which have had a positive impact, namely the Chancellor's pre-budget Report in November and the Competitiveness White Paper in December.

Through the pre-budget Report and the Competitiveness White Paper, the Government has clearly stated its desire to improve the science base within the UK, the commercial exploitation of research and new ideas and the creation of a more entrepreneurial society. Whilst changing the culture will be difficult to achieve and undoubtedly will take time to bring about, the following initiatives are welcomed and should go some way to the end goal.

- The DTI are providing £20 million of funds for the Reach Out Programme (HERO);
- Eight Enterprise Centres to be set up at UK HEIs;
- Development of a nation-wide network of Faraday partnerships;
- The doubling of support from the DTI to the Teaching Company Scheme;
- Provision of £10 million for collaborative projects under the Foresight—LINC awards;
- Corporation tax relief for research and development for smaller companies;
- Government and Welcome Trust funds of £1.4 billion to help modernise the UK SET base;
- The NESTA £200 million endowment for creative individuals;
- The development of an Enterprise Fund to include regional venture capital funds, together with the private sector to address the equity gap.

I hope that you find the above of use and if you require further comment or information, please do not hesitate to contact me.

*25 January 1999*

[30] First Report, Session 1993–94 (HC 74).

## APPENDIX 49

### Memorandum submitted by NCR Financial Solutions Group Ltd

1. Introduction

1.1 NCR Corporation participates in the $514 billion Information Technology (IT) industry. In October 1993, NCR announced its strategy to compete in the $201 billion Customer Information Solutions (CIS) niche of the IT marketplace by providing "Customer Focused Solutions". We define these as "information technology systems that create, capture, store, access/retrieve, update, and analyse customer information files, as well as the software, hardware, networks, and support and professional services used in the implementation, maintenance, upgrading, and enhancement of these systems." These systems enable our customers to get, move, and use information about their customers and prospective customers in their key business decisions. Customer information includes data about the characteristics, buying patterns, preferences, and requirements of our customers' prospects and customers.

1.2 Financial Systems Group (FSG) focuses on making financial services institutions more competitive by building a stronger relationship between the institutions and their customers.

1.3 Accordingly, FSG's longer term strategy is to transform itself from an organisation that is product-led with ATM's and item processing equipment to a solutions and applications-led proposition and ultimately to a full service provider.

1.4 *FSG's Relationship to NCR Corporation*

FSG's products and services account for approximately 13 per cent of NCR's total sales.

1.5 FSG's Charter is to:

- Develop and market transaction intensive financial services systems and products;
- Lead NCR's effort in providing total solutions to the Financial Services Industry by leveraging all of NCR's computer products, professional services and support services;
- Position FSG as "Creating the Markets of Tomorrow" through thought leadership, business understanding, innovation and technology leadership and partnering with customers and strategic alliance partners.

1.6 Our vision is to be a valued and compelling long-term partner of major Financial Services institutions around the world, improving the profits and competitive advantage of these institutions by helping them better understand and serve customers.

1.7 FSG has recently organised around four groupings; Self-Service Solutions, Payment Solutions, Consumer Delivery Solutions and Consumer Management Solutions. The key product lines we manufacture include:

- Self-Service Terminal (SST), NCR is the world leader in the shipment and installation of Self-Service Terminals;
- Image and Payment Systems;
- Consumer Delivery Solutions (CDS); and
- Data Warehousing Solutions (DWS).

1.8 *Identifying Our Target Markets*

FSG participates in the $69 billion Financial Information Technology (IT) market that accounts for 13 per cent of the Total IT market. The Financial IT market is segmented as; Securities (16 per cent), Insurance (25 per cent), Retail Banking (25 per cent) and Other Banking (30 per cent).

1.9 Our primary market focus is dominated by large financial services institutions throughout the world. Consumer (Retail) Banking products and services, the primary market, is projected to grow from $9.4 billion in 1996 to $17.2 billion in 1999. The forecast is that this growth will be primarily driven by the Consumer Delivery Solutions segment. Data Warehousing Solutions is the second largest growth area, increasing from $3.1 billion in 1996 to $4.1 billion in 1999.

1.10 *In support of our vision, the following key programs support the FSG Business Programs Model:*

- Automated Teller Machines;
- Non Cash and New Business Transactions;
- The Automated Branch;
- Integrated Channel Manager;
- Item Processing;
- Payment Systems;

— Consumer Delivery;

— Relationship Management Solutions.

1.11 The opportunity for these replicable offerings exist for our current and emerging markets and we can increase our return on investments by more fully utilising partners and new channels.

1.12 To fulfil our indirect marketing strategy, we target Channel Partners to sell NCR products and services to non-target NCR customers, both inside and outside our targeted industry segments.

1.13 NCR FSG has two main development sites, one based in Dundee Scotland and the second in Waterloo Canada along with numerous field based development sites around the world. In addition to the development sites focused on work directly applicable to the financial industry the world-wide development sites for NCR's computer (California, USA) and retail (Atlanta, USA) businesses also supply expertise as applicable.

2. Summary

2.1 In respect to the specific area's of interest expressed by the committee NCR Financial Solutions Group Ltd has some relevant input into two, which are Intellectual Property Rights and The Role of the EPSRC. We have however provided an outline as to our advanced development processes as this may give useful insight into how large technology development organisations work.

2.2 In the area of intellectual property and patents NCR as a whole is very aware of the importance of good patent coverage for its innovation. All developments are reviewed in detail prior to public disclosure to ensure that all new intellectual property is adequately covered. Most patents are filed in all major area's of the world. NCR also runs an employee recognition scheme to encourage as many people as possible to submit idea's for filing.

2.3 Within the UK operations FSG is involved with a small number of projects that attract EPSRC funding. The primary academic organisation that FSG is working with is The University of Dundee through the NCR Advanced Mechatronics Research Centre based within that institution.

3. NCR FSG Advanced Development Process

3.1 In order to ensure that optimum efficiency in Advanced Development spending all activities are controlled by a Divisional body known as the Technology Advisory Board.

3.2 The following defines the process steps, inputs and outputs for the activities to be conducted by the FSG Advanced Technology Advisory Board.

3.3 The Board's focus is to advise on:

Setting of FSG's Advanced Technology Strategy

Distribution of the Advanced Technology funding among the strategically significant areas

Evaluation of Advanced Technology Project Proposals

Review and Guidance of Advanced Technology Projects on a Regular basis.

Proposed projects have to go through a Selection Process.

3.4 This process takes as its primary input a Project Proposal which can originate from a number of sources collectively known as the Project Proposer. The project proposer is most likely but not exclusively to be from one of the following sources:

FSG Advanced Technology Team

FSG BSG Engineering Group

FSG Marketing Group

Academic Institution—Directed Call

Academic Institution—Fee Submission

NCR Customer via Knowledge Lab

NCR Customer via CFT

Knowledge Lab Research Associate

FSG Advanced Technology Group.

3.5 The project proposal is submitted to a central administration location for recording and distribution to the Technical Review Group (TRG). The Technical Review Group is made up of the Senior Consultants in the Advanced Technology Group and the CTO of the Advanced Technology Group. The Technical Review Group will be responsible for evaluating all proposals (initial and detailed) on their technical content, feasibility and costing. Any proposals that are rejected by the TRG can be submitted to the Advisory Board directly by the proposer, but extra information will be required to indicate why the TRG's decision was not correct. Only proposals that have been reviewed by the TRG will be accepted by the Advisory Board for review.

3.6 The Advisory Board will be Chaired by the CTO, Advanced Technology Group with its members being drawn from the Senior Management in the Technology and Marketing areas of the Financial Solutions Group.

The Board has three top level processes:

1. Definition Of Technology Strategy
2. Project Selection
3. Project Review.

3.7 The board will meet quarterly to review the current AT Strategy, new project proposals and the status of currently running projects. These meetings will be lead by a competent facilitator. All relevant comments and decisions will be recorded and stored in the project archive.

*4 November 1998*

## APPENDIX 50

### Memorandum submitted by NM Rothschild & Sons Limited

1. N M Rothschild & Sons Limited is a merchant bank operating in many countries and offering a wide variety of financial services including the management of venture and development capital investment funds, resource banking, asset management and corporate financial advisory services. We have wide experience of investment in innovative companies in many countries. We offer the following perspective to help the Committee focus their deliberations and provide a summary of the issues we believe should be addressed.

2. The scope of the Committee's enquiry is very ambitious. It represents a review of the nation's ability to design, manufacture and distribute innovative new products and processes and an examination of the role of government in enabling this to the best extent possible. We suggest the Committee consider sub-dividing the work into manageable pieces. Alternatively, the issues might be dealt with in stages beginning with the economic and policy factors that influence product and process innovation leading to a review of the policies and programmes of government funded research and its relationship with industry.

3. A global market perspective is essential. The key question is how do we create a national culture that promotes our natural innovative skills and applies them effectively to the introduction of high value, leadership products and processes in global markets. By contrast, there is limited and declining opportunity for cheap "me too" products as this role is rapidly becoming dominated by the new industrial economies. A strong "customer" or "user" emphasis is required. In summary, we must become a knowledge-based economy where knowledge and expertise enables us to be best in some important and valuable global markets.

4. Many factors will determine our success. We highlight those we consider deserve the Committee's attention.

4.1 The nation's competitiveness will be determined mainly by the quality of our work force and the leadership they are given. A well-educated and trained workforce is of paramount importance. Government policy is clear for initial education but, in addition, we must have a culture of life long learning to develop our cutting edge. Although the government is taking the first steps to tackle this important requirement, we need a significant culture change within employer organisations and in the workforce. This will require a kick-start and substantial support. Financing should be provided by a combination of the individual, the employer and government.

4.2 We must modify the incentive system between our universities and industry so that they are motivated to share strategic goals for both research and teaching. We need to create a strong climate of interdependency for mutual benefit, built on an intellectual partnership and less on altruistic donations. Changes in attitudes in both industry and academia are required: in industry to influence and support long term strategic research and in academia to give greater weight and reward for successful collaboration with industry. For example, the periodic research assessment exercise takes too little account of the university research conducted in collaboration with industry.

4.3 We need to strengthen our "industrial courage" to better assess, take appropriate and well judged risks, and provide leadership to succeed with global opportunities. This will require the development of more senior business managers in the industrial and financial services sectors able to directly assess and balance business and technical risks, and make investment decisions.

4.4 We must encourage and reward the individual innovators and the investors in them. Particularly, we must provide greater support for small innovative research based companies. History shows that much novel innovation comes from small committed and dedicated groups and there is no reason to believe that this will change. The availability of venture and development capital for such companies must be improved. At present, the provision of capital and loan finance for "start ups" and "research based" companies is very limited and difficult to raise in the UK. There are two principal reasons: a lack of technological knowledge in the financial services sector to properly assess the risks and inadequate incentives for private individuals to provide backing. The "tax shelter" mechanism to encourage high-risk investment by rich individuals should be extended to enable an individual to invest up to £0.5 million per year in approved schemes. Another

important issue for these companies is that the cost of realising wide geographic patent coverage is prohibitively expensive and we recommend this problem be examined. Legal aid to help small companies protect their intellectual property from infringement might also be considered.

4.5 The concept of a university based "ideas incubator" has considerable merit and a number are being planned. This involves the financial services sector and others creating a fund to provide loan finance for a collection of new and innovative ideas. A support organisation provides guidance and advice to the nominated projects. Contributors to the fund would be entitled to make equity investments in these projects at the appropriate time when a business plan has been fleshed out, a clear market identified and a management team selected. Government support through a tax shelter scheme could be very helpful.

4.6 We believe that the Foresight Programme has made a positive contribution to academic research priorities but the industrial commitment to engage in appropriate strategic research appears to be weak. The Programme seems to have lost inertia and needs to be revitalised. If properly focused, it could play a valuable role to strengthen industry/university bonding as discussed in 4.2.

4.7 The recognition that many technologies have dual purpose for both defence and civil applications needs further examination and development. We should improve the flow and interchange between the defence and civil sectors for the benefit of both. The Defence Establishment Research Agency (DERA) could have an important role here but needs to have the freedom to operate, in part unfettered from the Ministry of Defence.

## APPENDIX 51

### Memorandum submitted by the Office of Science and Technology

FOLLOW-UP TO SCIENCE POLICY RESEARCH UNIT REPORT TO TREASURY

This response relates to research in the general area of the relationship between publicly funded research and economic performance. The Economic and Social Research Council has funded research on the relationship between publicly funded basic research and economic performance in the following centres. In the short time available, it has not been possible to do a comprehensive review of all the research funded in this area but the following examples will give an indication of some of the research which has been carried out recently, funded by ESRC and other funders.

RESEARCH AT THE SCIENCE POLICY RESEARCH UNIT

The Treasury report written by SPRU itself reflected a stream of work which has been going on under the ESRC Centre for Science, Technology, Energy and Environment Policy which was established at SPRU in 1992 by the ESRC with funding of £2–£5 million over five years. The ESRC in making this award decided that it would be the final phase on a long period of support for the Centre. Since ESRC core funding ceased in September 1997, some of the research has continued to be funded by the EU (TSER) and individual ESRC projects. Relevant research projects include:

The Changing Shape of British Industrial Research. Diana Hicks and Sylvan Katz developed their research based on the Bibliometric Evaluation of Sectoral Scientific Trends (BESST) database which tracks UK scientific publications back to 1981 and enables detailed analysis of institutional and sectoral trends. They demonstrated that in the UK companies make regular and systematic contributions to the science literature. They show company research to be as highly collaborative as that of other institutions. In the life sciences, company research is more highly cited than academic research. In a world in which information and knowledge are increasingly recognised as being important corporate assets, they suggest that one of the most important reasons why companies publish is to send signals of technical credibility into a system where economic activity is increasingly knowledge-based and technical competence highly valued.

Hicks and Katz have also used their database to probe the science and technology relationships in industry, analysing the networks through which skills and knowledge are exchanged. These informal networks of "knowledge exchange" exist neither within the market system nor are internalised within the firm, but have been empirically proven to facilitate innovation. Those two researchers used co-authored papers as indicators of the networks underpinning science and technology links; using 14 years of co-authorship data to examine the UK system of informal industrial links the results show that industrial sectors differ greatly to the extent to which they network with university researchers. Nevertheless informal networking increasingly characterises industrial research. This suggests that industry, a site where research meets application, finds it worthwhile looking across the research system to pull in the knowledge and resources necessary to underpin its activities. The Centre also studied:

- Barriers to collaboration in hospital research;
- Bibliometric parameters as a measure of scientific activity;
- Does public funding of R&D crowd out private R&D?

von Tunzelimann has been working with Martin on econometric work investigating the "Kealey

Hypothesis" that public funding of R&D "crowds out" private funding and thus cutting government expenditure will actively boost total R&D. Their findings to date strongly reject this hypothesis. Indeed they indicate that government R&D is just as likely to "crowd in" industrial R&D namely to cause it to expand. They also find some evidence of a "reverse causation" by which changes in industry-funded R&D lead to offsetting responses by the government.

*Academic Research, Technical Change and Government Policy*

Pavitt has continued to explore issues connected with the benefits to be gained from basic research and the rationale for government support. Pavitt in his paper "National Policies for Technical Change" attacks mainstream economics for failing to recognise the importance of tacit knowledge transfers. He suggests that institutional competencies (eg in firms, government agencies) are just as important as incentive structures in explaining successful performance.

*Patterns of Internationalisation of Corporate Technology*

This research has suggested some evidence to support the view that firms are increasingly engaging in small scale activities abroad in order to monitor and scan new technological developments in centres of excellence in foreign countries.

*The Science Base and Locations Decisions*

Pavitt's research leads to the conclusion that continuous technical change in modern business firms requires the proximity of a strong, publicly-funded research base and associated training facilities. He goes on to argue that traditional national linkages between technological activities and the underlying science base are under increasing strain.

*Overseas Biotechnology Research by Europe's Chemical-Pharmaceutical Multinationals*

SPRU research (Senker) shows that while European small biotechnology companies may be starting from a lower base than their US counterparts, changes in regulation, an easing of financial constraints and increased collaboration between companies and universities are beginning to close the research and industrial gap between Europe and the US.

*The Nature and Dynamics of Knowledge Creation in Firms*

d'Adderio has researched on how organisations acquire and use knowledge in the innovation process. Several in-depth case studies on firms' product development activities have revealed the significant influence that advanced software technologies are now having in shaping the information and knowledge processes in product development.

*The Technology Strategies of Europe's Large Firms*

Patel has found that Europe's multinationals are more internationalised than their US and Japanese comparators in that they perform more of their corporate technological activities outside their home country base.

*Multi-technology Firms*

An increasing diversity in the technological competencies of large firms is caused by firms needing a broad range of competencies to handle/co-ordinate change in their supply chain of components, materials, etc. Firms also need to explore and assess new opportunities. Both help to explain why increasing product focus can go hand in hand with growing technological diversity and increasing external linkages.

ESRC Centre for Fiscal Policy, Institute of Fiscal Studies

New data on fiscal incentives for R&D has enabled centre researchers to study the effects of accounting and tax regimes on tangible and intangible investment in eight countries over the last 15 years. This research suggests that fiscal policies had important effects in stimulating domestic R&D spending, and may also cause substantial relocation of R&D from other countries. The impact of the introduction, or reform of fiscal incentives for R&D in the UK, France and Germany has been stimulated.

The Centre is continuing its work in examining the role of financial constraints on investment by examining relationships between company R&D spending, physical investment and finance in both Britain and Germany. Changes to accounting requirements in the late 1980's in both Britain and Germany allow this to

be studied using micro data for the first time. German firms invest more in R&D and it is often argued that this stems from the longer term horizons of investors and managers. Preliminary results suggests that the behaviour of UK and German R&D performing companies is more similar than is often believed.

An important dimension of the Centre's research into innovation is the impact of technical change on the labour market. There has been a rapid shake-out of low skilled workers in the advanced countries which many writers have associated with the computer revolution. In a four country comparison Centre research corroborates the importance of technical change but we also find that institutional changes in the labour market (especially in Britain and the USA) have a very important role in accounting for the upgrading in skills.

ESRC's Research in the Financial Markets Centre, London School of Economics

*Financing Innovation*

There has been much discussion about the importance of innovation to the overall competitiveness of the UK economy. The research undertaken at this Centre, under the auspices of the ESRC Innovation Project, has addressed one potential source of hindrance to innovation in the UK, namely the potential for the financial markets to misallocate financial capital to firms which conduct research and development. The project began in October 1994 and its goal has been to provide empirical evidence on potential financing problems faced by innovative firms in the economy.

The theory motivating this research concerns failures in financial markets arising from problems of asymmetric information. The thrust of this literature is that the price mechanism may fail to efficiently allocate financial resources if the suppliers and demanders of finance have different information about the expected future returns to the investment projects for which finance is being sought.

There are two main empirical implications of financial market failure: first, expenditures of innovative firms will be more sensitive to fluctuations in the amount of available internal finance; second, innovative firms may require a high degree of market power in order to generate profits sufficiently high to finance ambitious research and development programmes. The latter implication was originally hypothesised by Schumpeter, who used it in defence of monopolies.

An analysis of the physical investment expenditures of a number of firms over the period 1970–1993 showed that the investment expenditures of high R&D intensity firms were more sensitive to fluctuations in internal finance than those of low intensity firms. These results are consistent with the first of the above implications of financial market failure.

The second implication of financial market failure, Schumpeter's hypothesis was tested. The results indicate that market power is an important determinant of investment of firms which are R&D leaders within an industry.

*Centre for Business Research*

The ESRC funded Centre for Business research is carrying out work relevant to five aspects of the areas highlighted by the SPRU report:

— Technology Transfer from the Science Base
— Territorial Clustering and innovative Millieux
— SMEs and the Innovation Process
— Networks. Collective Learning and RTD in Regionally Clustered High Technology SMEs
— Surveys and Database Management.

*Technology Transfer from the Science Base*

Moore and Howells are investigating the extent to which the commercialisation of academic research has been successful in improving the competitive advantage of industry, and in particular to identify which modes of technology transfer and exploitation result in sustainable alliances and collaboration to the benefit of both parties.

The research will also assess the nature and extent of benefits to universities and the importance of a mutuality of interest in raising benefits and focus on which modes of technology transfer and commercialisation result in sustainable alliances and collaboration to the benefit of both parties, and which result in disjuncture. The relative importance of intellectual property rights, dominant design and market power and complementary assets, will be assessed for each of the case studies.

*Territorial Clustering and Innovative Millieux*

Moore, Keeble and Wilkinson are investigating the extent and nature of local inter-firm relationships and networks and addresses the questions of how far the core characteristics of the "Innovative milieu" apply to research-intensive firms in the Cambridge and Oxford regions.

They are studying the nature of the dominant technological, information, research and development and other linkages between firms themselves and between firms, research institutions and other private and public sector bodies in these two regions. The position of these firms within vertical supply chains, and the nature of local horizontal linkages in the areas of training and information-sharing, are central questions for study. A related question concerns the local activities of large national and multi-national firms and whether by locating part of their operations in Cambridge or Oxford and by their acquisitions of local firms they have restricted the extent and nature of regional provision of products and services which are external or internal to the firm; French research has highlighted the importance of this question.

*SMEs and the Innovation Process*

Cosh, Hughes and Keeble are investigating the role of SMEs in innovation. They have found that systematic high quality research on the role of SMEs in innovation has been hampered both by lack of data and by definitional problems. (Less than 150 replies were received in the UK section of the recent European Community Innovation Survey (CIS) organised by SPRINT/EIMS and EUROSTAT.)

The project is also developing a small number of selected case studies of firms who have maintained their innovative activity over the whole period 1987-95 and those who have not,. This will be complementary to a set of detailed studies of growth amongst a small number of our survey sample recently completed for the DTI as part of the Growth Constraints on Small and Medium Sized Enterprises project.

*Networks, Collective Learning and RTD in Regionally Clustered High Technology SMEs*

This European research network, which is co-ordinated and organised by Keeble and Wilkinson on behalf of the ESRC Centre for Business Research, brings together 11 European research teams from eight countries to study the role and importance of regional and European-wide research and technology linkages and networks in the evolution and competitiveness of regional clusters of innovative high-technology SMEs.

Specific questions which are being investigated and discussed at a series of Network meetings held in different European locations over the three years of the Network's activities are:

- how are these different regional clusters of technology-intensive SMEs evolving in the 1990s, and is it possible to identify more or less successful evolution trajectories in different regions?
- how important are local, European and international research and other linkages between SMEs for successful technology-intensive SME development in these clusters?
- how important are linkages between SMEs and local universities/public research institutes in these clusters, and what role do such linkages play in their development?
- what impacts do large firms have on the development of these technology-intensive SME clusters?
- what is the nature of, and how important for successful SME development are, "collective beaming" processes operating within these regions, and particularly their scientific and professional labour markets?

CONCLUSION

This short review has indicated some of the relevant research which is, or has been funded by the ESRC. Not all the topics suggested by the SPRU report have yet been researched. The pressure on ESRC funds is such that only a small proportion of the high quality researchers wishing to study topics of such high priority and interest are able to be supported.

## APPENDIX 52

### Memorandum submitted by Oilfield Systems Limited

INTRODUCTION

1. Oilfield Systems Limited is a UK company founded in 1984 to develop advanced software solutions for the oil and gas exploration and production market. The company is based in Southampton with offices in Aberdeen, Calgary and Houston. The company has developed GeoScene (a geological workstation), DAEX (a data migration solution), Quadrate (multi-screen handling for Unix computers) and FaMOUS (3D reservoir modelling system).

2. Oilfield Systems has employed between 10 and 25 people since 1989, with a current staff of 22. Revenues have grown to c £1.5 million per annum. The company has been only marginally profitable overall, mainly because of high continued investment in support and new product development.

3. Oilfield Systems has been a participant in two LINK scheme projects: Project No 7246 (FaMOUS: A new tool for geological modelling) and Project No 7256 (Improved hydrocarbon recovery through the integration of geological, petrophysical and engineering data from non-conventional wells).

## How First Learned About LINK

4. We originally heard about LINK through our contacts at the Offshore Supplies Office in Glasgow (now the Infrastructure and Energy Projects Directorate). That organisation had provided excellent support to our fledgling organisation in the late 80's by providing partial funding for our first major product development, GeoScene, which is today a successful software product.

## Why We Participated And Our Experience

5. In both cases, the academic partner had developed expertise, complementary to our own, which we considered could be developed commercially using our skills and experience of bringing successful software products to market.

6. In both cases, finding industry support was very difficult, taking a minimum of six months. In addition, one of the proposals had to be submitted twice to the LINK Committee before support was forthcoming. Once the award was made, the running of the projects was smooth and regular meetings between the partners and sponsor companies has ensured a free flow of information.

## Did Our Involvement Meet Our Objectives?

7. In both cases, progress has been less than that forecast. This is no criticism of the LINK Scheme, of the academic partner or of ourselves. Rather, the nature of the projects is, by its definition, risky and there are many unknowns to be tackled between innovation and commercialisation. In each project, we have contributed more than we intended.

8. Neither Project has yet yielded financial benefits (as net contributors we are significantly out of pocket) though each is expected to break even within the next year.

## What Impact has LINK had on our Company?

9. One of the main benefits has been the contact that LINK has mediated between ourselves and academic partners. This has, in turn, encouraged us to work more closely with academic institutions who are gateways to early adopters of our technology.

10. The funding from LINK to Oilfield Systems has only covered a percentage of our incurred costs but has nonetheless been very welcome and gratefully received.

## What Barriers Have Prevented Higher Gain?

11. LINK excludes marketing and sales effort from consideration as chargeable costs to the project. Today, more than ever, good products fail because of inadequate marketing and sales effort. To get the most of our nation's innovation we must recognise that good marketing and sales is as important as technical development.

## Overall Assessment

12. Positive. Any support to promote collaboration between sources and consumers of innovation is definitely a good thing.

13. The LINK Scheme, with its projects approval committee, sorts out viable projects from those considered inappropriate to the industry's current needs. However, more could be made of this in that approval by LINK should perhaps be a primary requirement for industry sponsorship. By working in concert with companies, the industrial sponsorship element would be more easily accessed, reducing the cost, effort and delay caused by seeking out industrial sponsors after LINK approval has been forthcoming.

*8 January 1999*

## APPENDIX 53

### Memorandum submitted by Oxford Instruments plc

1. Introduction

Oxford Instruments is a publicly quoted high technology company with origins in the University of Oxford. Sales of ca. £150 million per annum in instrumentation for healthcare, industry and research are supported by an R&D budget in excess of £10 million per annum net of additional research contracts. Exports and overseas sales amount to 85 per cent of revenues and the company maintains strong links to the science bases in the UK, the USA, Europe and East Asia (particularly Japan and Singapore).

2. Summary

Oxford Instruments plc wishes to draw to the attention of the Committee the central importance to our evolution as a company of fundamental scientific research carried out in a number of UK universities and Government Laboratories. Government schemes to promote collaboration between industry and the science base have also played a critical role in a number of our major development programmes. Looking to the future, we are optimistic regarding the provision of finance for new high technology companies provided that attention is given to the seedcorn/incubator sector. Overall, we are also strong supporters of the Technology Foresight Programme. We remain concerned, however, that the correct balance be maintained between the current emphasis on the industrial relevance of research and the pursuit of new knowledge which is not perceived to be of immediate application. World class excellence in Science and Engineering has been a central feature in our national culture for more than two centuries and we urge that fundamental research should continue to be accorded the highest priority as we move towards the new Millennium.

3. The Industrial Application of Government Funded Research

Virtually all the major technological breakthroughs in the development of Oxford Instruments have arisen from work originally carried out in the Government funded Science Base. Superconducting magnets, developed in the Clarendon Laboratory at Oxford University formed the early core of the business; nuclear magnetic resonance developments took place in conjunction with the Biochemistry Department at Oxford (under Sir Rex Richards); magnets for the MRI scanners were developed in collaboration with Sir Peter Mansfield's group at Nottingham (and others elsewhere). This tradition continues today in fields as diverse as the development of high field magnets, "down hole" NMR for oil exploration, gravity mapping, nanotechnology and high temperature superconductivity. (Also see 4 below).

4. Government Laboratories

In addition to the work cited above, a number of other developments which took place in partnership with Government Laboratories are worth noting, including:

(a) *The Helium Dilution Refrigerator*

Technology transferred to the company from AERE Harwell. Almost 30 years on, this product still enjoys (in its modern variants) a dominant market share in low temperature applications in materials and condensed matter physics.

(b) *Silicon Detectors for X-ray Analysis*

Also transferred from AERE Harwell to Link Systems Ltd—now, following its acquisition, the £20 million Microanalysis division of Oxford Instruments. The products are deployed in areas such as forensic science, semiconductor manufacturing and aerospace.

(c) *The "Helios" Synchrotron*

Developed in conjunction with the Daresbury Laboratory, this $25 million device may revolutionise the semiconductor chip industry early in the next millennium. Systems have already been sold to IBM in the USA and the NSTB in Singapore.

We would like to make it clear that the businesses which have been built on the basis of the technologies developed in these Government (or former Government) Laboratories would not exist today without the knowledge generated in those laboratories and in a number of cases the people transferred to the industrial sector.

5. GOVERNMENT COLLABORATIVE SCHEMES

The company is an enthusiastic supporter of the Government's schemes designed to promote collaboration between the science base and industry.

Examples involving Oxford Instruments include:

(a) *"Link"*

The 750 MHz NMR magnet developed with Oxford University and ICI; neutron radiography systems developed with Rolls Royce and Birmingham University.

(b) *Foresight Challenge*

The company, in partnership with EEV Ltd, Imperial College, London and Manchester Universities and PPARC is engaged in a major programme to develop new X-ray detectors for research, industrial analysis and medical applications.

(c) *Teaching Company Scheme*

A number of Teaching Company collaborations have been established within the operating business units.

(d) *Support for Innovation (SFI)*

The Helios synchrotron project (vi) was originally started with a £1 million SFI grant from the DTi—to which Oxford Instruments added £ many millions in further development expenditure, a clear example of "additionality".

6. FINANCIAL SUPPORT

In its earliest days, Oxford Instruments survived in the manner of many young SME's via bank loans and capital from the founders and their families. Financial stability, however, arrived in the early 1970's when 3 i's (then ICFC) brought in both new equity funding and encouragement to develop professional management. This investment was a turning point in Oxford's development.

Today, there are many more organisations within the investment banking and venture capital industries which can fulfil this role and it is our belief that ample funding is usually available for most young companies in high technology. If there is a gap, it may well be in the incubator/seedcorn area (cf Sir Martin Wood's activities at "The Oxford Trust").

Where a challenge does exist, we believe, is in the creation of a climate which encourages potential entrepreneurs, particularly in our universities, to "take the plunge" and establish their own start up company. Early results from a renewed campaign at Isis Innovation Ltd, Oxford University's IPR company, clearly demonstrate the latent enthusiasm for "spin-out" activities when finance, encouragement and professional advice are readily on offer.

More mature high technology companies will inevitably face the further challenges which lie ahead in the UK as a publicly quoted company. Much is made of the conflict perceived between the financial markets and such listed companies, little of which we would agree with ("you can't buck the market"). Nevertheless, it is interesting to note the relative lack of success of the London Market compared with NASDAQ in the USA in promoting high technology stocks.

7. "FORESIGHT"

Oxford Instruments is a keen supporter of the concept of "Foresight" and of the current programme. We see the main benefits as the extensive industrial/academic network which has been created, the sharing of values which has resulted from this networking, and the mutual respect and understanding between industry and the science base which has been enhanced by Foresight activities.

If there is a danger, we see it as what some would regard as the move towards "directed" research, perhaps at the expense of that which is often referred to as "curiosity driven". MRI, for example, is the product of good fundamental research, driven initially by a quest for new knowledge. Thereafter, awareness of the potential opportunity and serendipity played their parts—as well as good planning and "focus" when the opportunity was clearly identified.

We are anxious that in seeking to optimise the industrial applications of research in general we do not compromise the historic propensity of the UK's national science base for world class fundamental scientific discovery. Out of these discoveries, in both the life and the physical sciences, come the opportunities for industrial applications leading to wealth creation.

8. EPSRC

As the Chairman of Oxford Instruments is also Chairman of the Particle Physics and Astronomy Research Council, it would seem inappropriate for us to comment on the EPSRC. We would, however, wish to stress the central importance of the EPSRC's role and that we have very fruitful relationships with a number of university departments which in turn are funded by EPSRC.

9. Intellectual Property and Previous Recommendations

Finally, for reasons of brevity, we do not wish to comment at this time on either the issue of Intellectual Property or on the implementation the previous recommendations of the Science and Technology Committee.

*11 March 1998*

## APPENDIX 54

### Memorandum submitted by the Particle Physics and Astronomy Research Council

Introduction

1. The Particle Physics and Astronomy Research Council (PPARC), as one of seven Research Councils funded from the Science Budget by the OST (DTI) supports research, education and fellowships, and public understanding in the areas of particle physics, astronomy and space science. Its budget in 1997–8 was £192 million. The Council provides its researchers, mainly in the universities, with access to world-class facilities and funds the UK membership of international bodies such as the European Laboratory for Particle Physics (CERN) and the European Space Agency. PPARC is government funded. The Council has a responsibility to Government in its charter to ensure that the output of its science and technology research and education programmes is exploited, where possible, to the benefit of UK industry. The most assured benefit arises from the high grade scientists and engineers, many first attracted to study physics at school by the excitement of astronomy and space science, later exposed to major international research projects in the PPARC area, half of whom eventually find careers in UK industry or commerce. However, there is also direct benefit from the joint academe-industry development of the technologies demanded by PPARC's science agenda. PPARC is working to enhance these links.

2. Progress in particle physics, astronomy and space science is dependent on leading edge technologies which go beyond industrial standard products. This leads to innovation and development that would otherwise be unavailable to or from industry. Examples of current technologies include, superconducting magnets, high performance infrared and X-ray detectors, active optical systems precision lightweight structures, remote operations software, techniques for processing large data sets at very high speeds, and cryogenic systems. Some of these developments have already found their way into more everyday applications, for example MRI scanners (in health care), the World Wide Web (in commerce, etc), X-ray sensors (in dentistry) and infrared detectors (in night seeing devices). The Science and Technology Committee during its investigation into PPARC in 1996, received extensive evidence of the industrial benefits of PPARC science from a range of UK companies. British Nuclear Fuels plc: "UK companies benefit both in supplying key components and devices at the forefront of modern technology and by participating in development at the frontiers of what is possible thereby increasing their potential for spin off and wider industrial exploitation long-term...", Logica UK Ltd: "...space science has given rise to substantial industrial benefits...", Matra Marconi Space: "..the ESA Science Programme, funded by the PPARC subscription has a disproportionately large benefit to UK industry .." and Oxford Instruments plc: "..a huge outpouring over the years of enabling technology from particle physics.... has been captured by industry, health care and other researchers to the benefit of a very broad community indeed".

3. Since its foundation in 1994, PPARC has been working to improve the flow to UK industry of new technology developed in support of fundamental physics, and increase the number of its trained scientists and engineers who eventually work either with or in industry. This submission presents to the Committee PPARC's experiences and advice in the area of innovation and technology transfer. It does not address directly "the manner in which companies in the fields of engineering and physical sciences decide on developing new products and processes" which is outside the areas of PPARC's expertise.

Summary

4. PPARC has concluded that to ensure that industry has the opportunity to exploit the output of academic research in engineering and the physical sciences, Government and Research Councils should use their influence and resources to:

(a) encourage a culture of collaboration between academic and industry in which it becomes normal for highly skilled individuals to move between the sectors at any point in their careers;

(b) create communications networks which enable a higher level of interaction between academic and industrial researchers;

(c) encourage industry (particularly physics based industries) to be more willing to take risks and be more receptive to the potential for innovation based on research or technology produced in the science base.

## Fostering Technology Transfer

5. In common with most other bodies, PPARC believes that the most effective vector for technology transfer is people. UK inventions cannot easily be preserved for UK industry, particularly in the present era of international conglomerates and electronic communication. That reality underlines the importance of trained people, of course, since they carry with them key insights, but are much less mobile than pure information. PPARC is therefore keen to develop a culture in the academic research environment where highly trained and skilled people move to and from industry as a matter of course. The Science Policy Research Unit (SPRU) report to Treasury on the economic benefits of basic science identified both skilled personnel and advanced instrumentation as two of the most important outputs of the science base. A similar finding was made in the SPRU report for the Institute of Physics on "Physics and Industry" which reported that the links between basic physics and industry were complex, involving people, technologies and other science and engineering disciplines. PPARC's own study on post graduate career paths (by the Pieda consultancy) showed that young people trained in PPARC subjects acquired skills that were valued by industry, and have no difficulty in moving to careers in industry or commerce. That report, based on the experience of two cohorts of postgraduates from 1986 and 1988, showed a high degree of employability, with half now outside of the PPARC research community, and 83 per cent recalling their PhD training as being essential or of value to their chosen career.

6. Taking note also of the high quality and demand, PPARC has significantly increased the number of postgraduate students supported, with the specific aim of increasing the potential supply to industry, and supports a number of schemes (see below) directed at promoting a culture of collaboration and technology transfer. PPARC discourages universities from promoting the view that an industrial career is second best to an academic one, and believes that HEFCs should be encouraged to give greater recognition to industrial collaboration in the Research Assessment Exercises.

7. Government can also promote technology transfer and research collaboration by encouraging more and better communication between academe and industry. This was one of the primary aims of the Foresight programme, which can make a major contribution in this area. However, Foresight should concentrate on creating communications networks and identifying long term research needs rather than attempting to identify short to medium term research projects. PPARC welcomes the consultation exercise undertaken by OST to define the methodology for Foresight 2000. PPARC is operating its own equivalent of a "foresight" exercise in the construction of its Long Term Technology Plan. By making long term plans for technology development, PPARC plans to ensure that its community is provided with the instruments essential to future scientific competitiveness and to encourage the involvement of industry in the development, delivery and exploitation of the technology.

8. The NERC initiative NEST (the Network for Exploitation of Science and Technology) is an on-line web based research information forum using data from Research Councils and other sources. Currently still in the developmental phase, NEST should prove a simple and effective way to provide useful information on current research interests in academe, the Research Councils and industry: PPARC has produced its own database of the technological expertise in its academic astronomy and particle physics community. This has been widely distributed to industrialists seeking technological solutions.

## Schemes to Promote Research Collaboration and Industrial Application

9. The PPARC research community is focused on research in fundamental physics, which is, by its nature, unlikely to be of commercial or industrial interest in the short term. As a result, there has traditionally been less collaboration with industry than in research areas of more immediate application. Where the PPARC community has worked with industry, it has concentrated on improving existing technologies, or developing new technologies, to meet specific research equipment requirements. PPARC has developed and introduced a range of schemes to foster a stronger culture of industrial collaboration and technology transfer, as described below.

10. The PPARC Industrial Programme Support Scheme (PIPSS), encourages long term relationships between UK researchers and UK industry by funding (through a research grant) the academic side of research collaborations with industry on subjects of common interest. The operation of PIPSS is kept as flexible as possible in order to ensure that collaborations may be established which suit the needs of the interested parties. It is designed to help develop novel research technologies up to the point at which commercial application can be demonstrated.

11. PPARC, like other Research Councils, also offers Co-operative Awards in Science and Engineering (CASE), a PhD research studentship designed to give students industrial experience by providing research,

training and supervision of the student by a university and an industrial firm. However, in response to industrial representation, PPARC has in addition developed a strengthened "CASE-Plus" scheme which additionally offers students an extra (fourth) year of support working as an employee of the industrial firm at a postdoctoral salary level. PPARC has also recently become a sponsor of the Royal Society Industry Fellowships scheme. This scheme supports the movement (in both directions) of more senior scientists between academe and industry.

12. The Teaching Company Scheme (TCS), of which PPARC has recently become a sponsor, is specifically aimed at technology transfer through people. Funded in part by the DTI, it is widely regarded as one of the most effective technology transfer schemes. Indeed, the recent quinquennial review of TCS recommended its expansion after finding it to be highly effective in both technology transfer and economic impact. The scheme is also attractive because it is supported by a team of consultants who broker new relationships between universities and companies, especially SMEs.

### IPR and Patenting

13. It is PPARC's policy that any results derived from funded research showing commercial potential, whether patentable or not, should be exploited. Arrangements should be made to secure a suitable return to the institution and the investigators. However, PPARC has received advice from industry that, if interpreted too narrowly, universities' concerns to maximise revenue from licensing can be a barrier to successful exploitation.

*11 March 1998*

## APPENDIX 55

### Memorandum submitted by Pilkington Optronics

"To inquiry into the manner in which companies in the fields of engineering and physical sciences decide on developing new products and processes and the factors influencing their decisions with particular reference to the industrial application of Government funded research".

### 1. Introduction

Pilkington Optronics designs and manufacturers electro-optical systems, modules and components mainly for the defence industry and is one of the largest optronic solution suppliers in the world. With an annual revenue of £115 million and sales to over 50 countries Pilkington Optronics is a truly global company.

Over the last five years the company has invested in two new facilities (in Scotland and in north London) and has greatly modernised its third facility in North Wales.

In particular Pilkington Optronics with the Defence Evaluation and Research Agency have developed an extremely high resolution thermal imager using a long linear array detector. This imager is known as Stairs'C' and has world leading thermal imaging performance. The United States are developing a similar sensor (called SADA) which although not quite meeting the performance of Stairs'C' is likely, through the economy of scale, to be lower in cost to manufacture.

### 2. Summary

Pilkington Optronics supports the Government policy of competition but within an environment where competition enables a healthy growth of an essential indigenous capability. New Product Development, in particular that fostered by UK Government partial support, must be focused to meet a need. The co-ordination of the Government need and the government sponsored research is essential for the health of the industry.

### 3. IR Sensor Technology

The need for competition in the MOD procurement process is not questioned—however it is clearly in the national interest that the competitive process does not unnecessarily escalate the eventual cost of the in-service product and that the procurement of overseas technology (particularly from the US) does not dilute the indigenous national capability.

Pilkington Optronics reinvest some 8 per cent to 10 per cent of our turnover directed at future product in R&T it is essential that we invest in the right things.

Although we are prepared to invest some of our R&T funding in more generic and underpinning research, and somewhat more on process improvement and engineering efficiency, most of our investment must be structured around specific military functions. We can increase the efficiency of our engineering process as much as we like but unless we focus on the right programmes we are wasting our investment.

*In short we must do the right things and we must do the right things at the right time*

Only when the integrity of the need is sound will industry obtain a return on investment through series production.

We take much of our lead from the national defence research organisations such as DERA and it is a fact of the matter that the research community at some levels within DERA have too strong a vested interest in their own research programmes to make objective judgements on the correct directions of research and are consequently often the last people to determine the research programmes in which we should invest.

It is essential therefore that government clearly specify the need. It is only with a clear understanding of the need can Industry be in a position to make the right judgement in response to this need by aligning their PV investment to meet it. In addition the timing of the need is required to be clearly understood.

The STAIRS C Technology Demonstrator Programme is an example where the partnership between UK industry and MoD has achieved a world leading thermal imaging capability but, to date, has lacked the necessary co-ordination to enable success:

— The jointly funded Mod/Pilkington Optronics STAIRS "C" programme has demonstrated World leading thermal imaging performance, PO have continued to invest to enhance the target identification capability of the DERA demonstrators.

— A Technology Demonstrator Programme (TDP) in isolation with future procurement on a case by case basis and export restriction creates uncertainty for UK industry. Under these circumstances further investment is difficult to justify.

— The structured and fully funded US SADA technology offers a short term lower performance alternative for key UK programmes, but its use would lead to certain death of an independent UK capability followed by high US prices and limited access. Exploitation of future leading technologies from DERA will be difficult without a successful revenue generating industry.

— Co-ordinated procurement to achieve commonality of high performance EO would yield cost, risk and time scale reductions for MoD. Additionally, relaxed export control would increase pay back for both MoD and industry. The UK's 1st generation TCM programme was highly successful, 9,300 units have been sold, the majority of these were exported generating significant levy revenue.

— Pilkington Optronics propose a continued partnership with MoD to establish 2nd generation modules based on STAIRS C which would maintain the UK's world lead in night vision.

There is little point in our investing heavily in a Government sponsored IR Sensor programme such as Stairs "C" if at the completion of the development programme there is no programme with the sensor need and it is additionally frustrating if we are also not free to sell the technology overseas. It is even more frustrating if any need should be satisfied by overseas procurement and we are still prohibited to sell freely overseas.

*22 October 1998*

## APPENDIX 56

### Memorandum submitted by Queensgate Instruments Ltd

INTRODUCTION

Queensgate Instruments Ltd is an SME which designs and manufactures test and measurement equipment for the telecommunications and semiconductor industries. The company has participated in three LINK schemes. The first involved evaluating polymer bearings and the others the development of distributed fibre-optic sensor systems.

FIRST AWARENESS OF LINK

First awareness was through contacts within the university system. In the mid-1980s Queensgate was developing a range of products for positioning and position sensing with nanometre precision. Engineers and managers were in contact with National Physics Laboratory and Warwick University staff who were assisting in evaluating prototypes.

Queensgate subsequently became partners in the first LINK Nanotechnology scheme, with Warwick University and Rank Taylor Hobson.

I was invited to join the Nanotechnology Steering Group, and made other contacts which eventually led to Queensgate being a partner in a LINK scheme (fibre sensors) managed by Kent University.

### Objectives

Yes, the development objectives of the proposals were met in both cases. But the unstated objective of establishing close and lasting relationships with the universities involved was also met.

### Impact of LINK

The schemes allowed easy access to the academic institutions involved and *vice-versa* for them to Queensgate. Our engineers now recognise and appreciate the valuable role that universities can play in new product development.

### Barriers

Continuity of funding after the first Nanotechnology scheme was a problem in that the universities then turned their attention to other sources of funds, which inevitably meant other types of project. Queensgate were unable to continue the more basic collaborative research characteristic of LINK.

### Overall Assessment

Excellent vehicle for encouraging collaboration between industry and universities, but the lack of longer-term commitment ensured that all of the potential benefits were not realized.

*31 December 1998*

## APPENDIX 57

**Memorandum submitted by RDP Electronics Ltd, Wolverhampton**

### 1. Introduction

RDP is an SME which was formed in 1966 to design, manufacture and market Transducers (sensors) and Measuring Instrumentation worldwide.

It is now a leading manufacturer in its field but its current technology has diminishing future potential.

Development of new products using new advanced technologies is an imperative for the longer term success of the Company.

The Company had already established contact with a University to investigate the potential of Fibre Optics and Photonics as a measuring technology for the future and it was through this contact that we learnt of the "LINK Photonics Programme".

Development work in this area of technology can be very expensive so we decided that the "LINK" scheme would be an ideal way to get help to pursue the investigation of our ideas.

Our application for a "LINK Photonics" grant was made very easy by the Project Co-ordinator who gave us a great deal of guidance both in the initial application and throughout the project.

### 2. Objectives Surpassed

The main objective was to create a "photonic" measuring technique which was novel and would enable the development of intrinsically safe, medium accuracy, robust but relatively low cost transducers for the measurement of position/distance. In the event our objectives were more than met and the project has resulted in:

- (a) A number of Patents being registered.
- (b) Discovery of a novel measuring technique, with wide ranging potential, which uses a simple laser diode as the transmitter and sensor.
- (c) RDP has been introduced into a completely new field of technology which has exciting potential for the mid to long term development of the Company.
- (d) The newly qualified PhD Graduate who worked on the "LINK" project at the University has joined RDP and is currently continuing the development phase on a number of new products.

These are obvious benefits but there are many other less definable ways that this project has succeeded.

### 3. The Impact of "LINK" on the Company

The Company has learnt a great deal from its involvement in the "LINK Photonics" programme, for instance:

(a) We have learnt that it is very easy to work with a University to explore new technologies and the mutual benefits can be considerable.

(b) A great deal can be achieved for a very modest outlay—important for SMEs who sometimes find it difficult to generate and retain sufficient funds for research and development.

(c) A mutually beneficial and possibly permanent relationship has been cemented between RDP and the University, thus making available a wealth of knowledge in many fields of technology and science.

(d) The Company is now seriously involved in the final development of novel products in a new and more advanced technology, ie Photonics and Fibre Optic sensing.

(e) RDP continues to fund PhD students at the University so that the joint research can continue on a mutually beneficial basis.

(f) Our involvement with the advanced academic world has immensely improved the whole ethos of RDP's development laboratory.

4. Could We Have Gained More From "LINK"?

We cannot say that there were any barriers preventing RDP gaining from the relationship engendered by the "LINK Photonics" project, although its success obviously relies upon the mutual determination of both parties.

Given this determination there is absolutely no reason why this LINK scheme, for bringing together academic and industrial parties, should not succeed and provide substantial benefits for all parties.

It was our experience that help was readily available from DTI staff when required and the whole organisation of the administration could not have been more user friendly.

5. The Verdict

We believe that the "LINK" scheme is an excellent way of "pump priming" SMEs into the development and exploitation of new technologies. It is reasonably easy to administer but demands a sensible level of "beneficial" organisational rigour. This is good for SMEs.

We have found that everyone at the DTI including the Co-ordinators have been extremely supportive and helpful throughout the project.

This scheme can produce really positive benefits to SME and academic partners and will, in many instances, lead to a continued working relationship between the participants.

SMEs are generally nervous about getting involved with academic establishments, but this scheme gives the opportunity, with some financial help, to prove to themselves that such relationships can indeed be very beneficial in many ways.

If this message could be conveyed to all SMEs it could help to transform the performance of the UK in discovering and exploiting new and sometimes unique products.

Nothing could be more important to the future success of British technology in today's rapidly changing world markets.

The scheme as it is administered today seems to work well and is certainly not onerous. If it needs any improvement at all, I would suggest that it is in the area of PR.

I am sure that most SMEs are completely unaware that such help is available to them, sometimes for very modest outlay.

Universities are a huge, but largely untapped source of knowledge and academic excellence and the important issue is how to bring these together with SMEs who often have a dire need for their expertise.

Perhaps it would be appropriate today to devise a central "Internet" Website to act as a "clearing house" which could bring together academic and business partners to work on areas of mutual interest and to publicise this widely to SMEs and the academic world.

*14 January 1999*

## APPENDIX 58

### Memorandum submitted by Renishaw plc

1. Introduction

1.1 Reinshaw plc was formed 25 years ago, and is now a world wide company employing about 1,500 people, most of them in Gloucestershire. Our main product line is touch trigger probes for the machine tool industry. This product was invented by our Chairman at Rolls Royce to solve a problem with Concorde's

engines. Our Deputy Chairman left Rolls Royce to exploit the idea, and now the company has become the World Leader in probes. The company has a turnover approaching £100 million per annum.

1.2 Our involvement with the LINK scheme has been mainly to develop new product lines for the company, which are then marketed through our overseas subsidiaries and agents.

2. Summary

2.1 My personal experience of the LINK schemes are that they are very successful. However, there are a few problems associated with the submission process, and some minor ones in running the programmes, but the benefits, in my view, far outweigh the problems. However, the areas where improvement should be made are the publishing of the assessment criteria before proposals are submitted, and the feedback on rejected proposals.

3. Learnt About LINK

3.1 Renishaw learnt about the Link schemes through the EPSRC contacts of one of our Managing Directors—Professor David Pitt.

3.1 *Reasons for Participating*

3.1.1 The initial reasons for participating in our first LINK scheme were:

(i) For our prime UK optical component supplier to look into manufacturing methods so that their optical components could be manufactured at a suitable price, so that the overall project would be commercially viable.

(ii) To allow Renishaw Transducer Systems Ltd, as we were known at the time, to employ a larger R&D department then our turnover permitted, thus allowing for greater cross-fertilisation of ideas.

(iii) To further develop ideas which we had been jointly considering with Universities and our optical supplier.

Since our initial project Renishaw has participated in other LINK projects. Our main motives for these schemes have been:

(i) Get the Universities to take their ideas further than academic publications, and verify their processes in an academic environment.

(ii) To further develop the concepts which we had devised by the University.

(iii) Do the technology transfer and look into the production and commercial viability of the project.

(iv) To introduce new products sooner, because the LINK schemes allow us to employ more people in the R&D section.

3.2 *How easy or otherwise we found it in starting a LINK scheme*

3.2.1 Initially, we found the process of achieving funding for a project comparatively easy. However, since then the vetting procedure for LINK schemes seems to be more middle management orientated. For example the Gantt chart needs to demonstrably show transfer of ideas and links between partners. This in theory demonstrates on paper that the partners can and will be communicating with each other. In practice whether the partners actually talk to each other is not controlled by the Gantt chart but upon the aims of the individual institutions and personnel involved. I now have the impression that too much emphasis is now placed on middle management procedures, and not enough on the viability of the concept and whether the consortium is suitable for the project. (This criticism applies even more to the EPSRC, where I have heard too many academics say "It's a waste of time applying for a grant unless it has already been done in the USA").

3.2.2 My experience of LINK schemes is that I have more problems from the contracted coordinator rather than from DTI personnel. On several occasions I needed clarification on a particular point and the advisor was misleading, whereas the DTI employees were trying to be helpful within their permitted remit. I have felt that from most of the contracted coordinators they were more interested in obtaining bids before the committee. Whereas the correct advice should have been not to submit, because the scheme did not fulfil the committee's ground rules. The obvious question to ask is why does the coordinator need to be someone from outside the DTI? Given a stranger to discuss our proposals, I am happier with a civil servant than an outside contractor, because the civil servant is well trained in confidentiality. With an outsider, we have to check their industrial background, to find out if there may be conflicts of interest between their new role, and their old industrial contacts. All this takes time and human resources.

3.2.3 One of the ground rules which some LINK scheme committees have adopted is that one must have an end user as a partner. This has blocked Renishaw in submitting some proposals for two reasons:

(i) With respect to some projects all our potential customers are overseas (non-European in one case), so by definition a successful exporting company could not benefit from the LINK scheme in that instance.

(ii) With respect to our main market place, we are the worldwide main supplier, thus it is unfair for us to involve a UK customer in our product development, to the detriment of other UK and worldwide customers, by giving them an unfair advantage over our other customers.

3.2.4 Thus what appears to be a very reasonable suggestion for ensuring the success of a project, actually prevents LINK scheme partnerships from forming.

3.2.5 Yet another problem we have with LINK schemes is how open we can be with some of our ideas before the committees. In theory they are bound by confidentiality, but, in practice, we can not rely on it.

3.2.6 The question about who owns IPR is always a tricky one. With potential industrial partners, Renishaw has always taken the view that the partners should be vertically linked, not horizontally, ie one partner is the component supplier, another the instrument builder, and perhaps an end user. It is possible to have more than one component supplier providing they are supplying radically different items. It is also possible to have more than one end user, but they must come from different market places. The problem with the latter is that it can defocus the project. Thus with IPR negotiations Renishaw has not had problems with the industrial partners. This is not true with the academic partners. With a couple of institutions they wanted their royalties regardless. Our companies' view on patents has been: we would only be prepared to pay royalties on commercially significant patents. We have adopted this approach for two reasons:

(i) It would make it financially worthwhile for the academic institution to pay for an accountant to negotiate the royalties.

(ii) It only then makes sense to commercially defend a patent through the courts (typical figure—$4 million in the USA). If we are defending the patent then we would expect the academic institution to pay their share of the costs, because if the patent suit fails we would stop paying royalties. Why should Renishaw pay royalties on some IPR which the courts have decided is either in the public domain or belongs to someone else?

3.2.7 With some academic institutions it has been a hard struggle to convince academic commercial negotiators that it is unrealistic to adopt the approach that Renishaw would pay royalties regardless.

3.2.8 I now have the feeling that it has become considerably easier to negotiate with them, as their demands have become more realistic as they have gained experience.

### 3.3 *Assessment criteria*

3.3.1 The one area which needs improvement in the submission proposal phase is the inclusion in the guide lines for submission clear statements by which proposals will be assessed—the assessment criteria. This will enable me to submit the proposal in a manner which can then be clearly judged against their criteria, and, when the proposal has been rejected, it would then be easy to obtain clear feedback why the proposal was rejected.

3.3.2 It would be helpful if there was a clear indication of the expected level of funding for a proposal. At the present moment this is achieved by having a long conversation with the DTI representative, and interpreting the answer. After all, the scheme has been running sufficiently long now, the coordinator should be able to write down the bands without too much difficulty.

3.3.3 During the assessment procedure I have definitely been left with the impression that getting the middle management procedures correct to be more important than the concept. I wonder if this was because the committees have had projects fail because the consortium were not communicating between partners.

### 3.4 *Problems with running a LINK scheme*

3.4.1 To ensure communications between partners, project monitors are now requesting three monthly management meetings. At the start of the project this may be a sensible idea, but after the first six months it is not. Meetings do not get the partners to communicate. In practice, I have seen them hinder communications, with partners taking the attitude "we will see them in a month, it can wait till then", rather than fax or e-mail the problem. Holding meetings does not ensure that the partners will communicate with each other, although it may help. The project is failing if it takes project management meetings to get the partners to talk to each other.

3.4.2 One of our in house rules with respect to LINK, or any other schemes, including European, is that the number of partners within the project should be small. The larger the consortium, the more difficult they are to manage, ensure good communication between partners, etc and more likely that the personal agenda of a partner will be to obstruct the project. This will not necessarily be done deliberately, but it will be the consequence of their actions. (When we broke this rule and joined a large European scheme we saw this happen, and hence that project failed).

4. Success of LINK Schemes

3.4.1 Generally our involvement with LINK schemes have been commercially successful in terms of increased turnover and profitability for our company, and for UK limited in our ability to market such products worldwide. The tax we have already paid on those products developed under our initial LINK schemes has more than repaid the Government's contribution to the whole project. This comment does not include the tax paid by our partners. Also we have met our short term objectives: increased personnel in the R&D section, and the speeding up of products to market.

3.4.2 Recently Renishaw has become involved in some more LINK schemes. However, commercial viability of these projects will take longer to establish, namely because these projects are outside our traditional market place and the additional procedures required (one project is associated with the medical industry and cancer detection). One of the advantages of LINK schemes is that it does permit a company like ourselves to explore different markets and to expand into different product areas.

3.4.3 We have had one unsuccessful LINK project, but that was when our commercial partner's corporate body decided to close down their corporate UK research facility before they had completed their part of their R&D programme. This meant that they were then unable to supply the components we required for our commercial exploitation of the project.

3.4.4 Thus Renishaw has met its LINK objectives, both commercially and in personnel terms: being able to recruit people sooner, give them the experience of working with academics, and training them so that they get the relevant information from academic partners so that the company's commercial objectives can be met. The LINK scheme has also met our objectives in that by having a non rigorous commercial relationship with our suppliers, our understanding of each other's requirements has radically improved.

4. The Impact LINK has had on the Company

4.1 The major benefit of the LINK schemes on Renishaw are:

(i) It has significantly helped Renishaw with respect to totally new product lines which have become significant for the company.

(ii) It has helped Renishaw develop a product which was completely outside Renishaw's traditional market place, and has now become a world leader in its field.

(iii) It has improved Renishaw's contacts with the DTI. Not only does a Managing Director know people within the DTI, but the Engineers as well.

(iv) Indirectly, LINK schemes have improved our relationship with NPL.

5. Barriers

5.1 Renishaw would like to have formed partnerships with NPL and DERA under the LINK scheme, but with the Government treating them financially as if they were academic partners makes this concept for Renishaw more or less a financial non-starter. Their costs are high compared to Universities, and on speculative projects it is hard enough to persuade the board that a project is worthwhile as it is, even though the LINK scheme has a proven track record within the company.

5.2 The barrier to LINK schemes, which I fortunately have not met yet, is when I know that my key commercial rival sits on the committee. Under those circumstances, I would not submit a bid.

6. Overall Assessment

6.1 I think that the LINK scheme has been successful, both for Renishaw and for other UK companies. The scheme would benefit from minor rule changes, but not from a radical reform. The LINK scheme has made a considerable progress in making academics in this country more commercially aware of the needs of UK Ltd, and that UK Ltd has to pay its way. I still think this task is still not yet complete.

*29 January 1999*

# APPENDIX 59

## Supplementary Memorandum submitted by the Royal Academy of Engineering

## POINTS OF CLARIFICATION WHICH AROSE FROM THE GIVING OF ORAL EVIDENCE IN MAY 1998

### 1. The European Patent Office (EPO)—Fees

It is understood that a proportion of renewal fees paid to the EPO is received by the United Kingdom Patent Office to offset its own costs, as opposed to such contributions being paid direct to the Government. The precise details are not available to us and this is more a matter for the UK Patent Office. The level of fees will always be too high(!) but the view is that they are not exorbitant.

### 2. The "Opposition" and "Kort Geding" Procedures

This area which covers two inter-related aspects is very complex and it is not clear what the procedures allow and disallow, and case law is evolving rapidly. The difficulties arise mainly from the interaction of the Brussels Convention and the EPO tiered structure, ie the EPO forms a decison on an application for a "European Patent"; anyone can lodge an objection to the EPO decision which is reviewed by the "Opposition Division" and in time the "Opposition Division" view can be further challenged by a case to the "Appeals Division".

Anyone can oppose, without having to show any reason or argument, and the case may be heard by an official who has no experience or expertise or, indeed, interest in seeing justice done and the net result is possible confusion, at a cost more likely to affect the defender than the opposer. In one particular case, a company obtained a European Patent. It was opposed by a third party; the opposition was upheld and then squashed by the Appeal process. The third party, who had objected in the first place, when offered a licence on the patent, declined! Thus although the company was successful in the end, it suffered commercially through timing and the doubts case, and all parties lost because of the resources, which have to be paid for, used by the European Patent Office.

The Brussels Convention allows for a party to seek cross border declarations on validity of a granted European Patent. For example, it appears that a party may ask, say, the German Court to make a decision on validity of a United Kingdom or, say, Dutch Patent stemming from the European Patent. This is bizarre to say the least. It does not seem to be fair to the holders of patents because "opposers" can pick and choose the country where they think they will have the best chance of success. If all the countries in the EU had the same standards of approach, consistency and rigour of practice this might be acceptable. In reality these requirements and their interpretations also depend on culture and language and cannot, it seems, be imposed by directive. It would be more satisfactory for the scope of the Brussels Convention to be reduced if innovation is to be encouraged.

The Kort Geding procedure is another example of European muddle. It allows for infringement actions in one country to be translated across national boundaries. For example, a case of alleged infringement in one country may be heard in another country possibly even where no infringement may be an issue.

### 3. Improvements

The British system is viewed as simpler, less bureaucratic and fairer than the European approach. Comparisons of one regime with another are difficult because of the subjectivity involved.

However, from the comments above the European system ,which is fairly recent, needs some surgery. Not least if it is to stay, it should have a "filtering" process to prevent frivolous "opposition" cases. It could benefit from perhaps adopting the fairly recently introduced UK practice of the "Patent County Court" review of patents. This offers a professional, timely and relatively low cost approach, compared to measures of last resort, ie a full High Court action. The UK patent system overall is well tried and has evolved over a long period.

The UK system allows for relatively low cost action to seek to revoke a patent. However, as there is no automatic right to challenge a British patent (with a UK/EP patent there is) it is more likely that only those with a serious interest will do so. Therefore, it is suggested that the "opposition period" allowed for in European Patents (nine months from date of grant) should be dispensed with or much reduced.

*27 January 1999*

## APPENDIX 60

### Memorandum submitted by the Scottish Software Partner Centre

The Scottish Software Partner Centre (SSPC) is a joint initiative between Hewlett Packard (HP), Scottish Enterprise and Lothian and Edinburgh Enterprise Ltd. It was opened in February 1992 to accelerate the development of Scottish Software companies and to provide Hewlett Packard with an on site source of software products and services to assist the business at South Queensferry (SQF).

When opened it occupied 12,000 sq ft of purpose built office space and expanded to 20,000 sq ft in late 1993. At the height of its activity it contained some 23 partners engaged in various software businesses.

The current position of the SSPC is that it has now been reduced in size to 10,000 sq ft and only contains four partners, who are closely linked with HP SQF business requirements. This down sizing is due entirely to HP's need for expanded space requirements at SQF, however there remains a continued demand from many other potential partners.

The SSPC was the first of its kind in the UK and its success, since it was opened in 1992, has been the model for similar centres known as "Softnet", a large majority of which are not directly associated with companies like HP, but have been opened and have grown to 20 centres in the UK and two in the USA, with a third site being sought there.

In all, 85 companies have been assisted since the creation of the SSPC and during the life of Softnet. The companies involved have employed 400 professional staff and representing a gross annual turnover in excess of $46 million.

Please find below details of the advantages and disadvantages of hosting such a centre. This is based on the SQF example, the fact that space was available at the time of its conception and that the agreed rental is adequate to cover all the site services made available to the partners.

*Advantages for Partners:*

- Credibility in being associated/hosted by HP;
- Potential business relationship with HP;
- Fully serviced and furnished accommodation in flexible self contained units suitable for their business;
- Staffed reception area, conference rooms and car parking;
- Access to demonstration equipment, cafeteria and recreational facilities;
- Access to international sales network, training assistance, financial and business planning;
- Access to HP's distribution channels around the world;
- Easy access to HP's knowledge base of design tools, process and project management.

*Advantages to HP:*

- Occupancy rental from otherwise vacant office space;
- Resultant reduction in occupancy costs for existing SQF site businesses and hosted entities;
- Excellent publicity for HP in the Scottish business community;
- Provision of possible software partners or subcontractors "in-house";
- Possible goodwill and sales outlet for HP products and systems.

*Disadvantages for HP:*

- Should HP require expansion space, used by SSPC quickly, contractual matters could make this difficult;
- Possible high cost of rehabilitation of SSPC space when required by HP if different configuration is needed;
- Puts extra pressure on Site Services, for example:
  - Car Parking
  - Cafeteria
  - Facilities manning
  - Social Club facilities
  - Conference and Training rooms
- Requires additional accounting processes, administration and legal definition;
- Possible exposure of HP's "Intellectual Property";

— Increased site security risk;

— Increased site visitors.

*20 January 1999*

## APPENDIX 61

### Memorandum submitted by Silsoe Research Institute

INTRODUCTION

Silsoe Research Institute is one of the eight research institutes grant-aided by the Biotechnology and Biological Sciences Research Council. Our mission is to meet the needs of the agri-food industries through excellence in engineering science and innovation. Our major disciplines are engineering, physics and mathematics and our particular expertise is in applying these at the interface with biology. We have a range of customers, including BBSRC, MAFF and industry, for a balanced programme of basic, strategic and applied research. We have a successful record of technology transfer into our customer industries, including two Queen's Awards for Technological Achievement, and 34 current patents with 16 licensees. In 1997–98 18 per cent of our income was from industry and industry-related contacts such as LINK.

SUMMARY

Silsoe Research Institute has a successful record of transferring the results of Government-funded research to the agri-food industry. This is due to our policy of maintaining a balance of basic, strategic and applied research, and building good customer relationships with our industry. Increasingly, however, we find it difficult to attract strategic funding from Government to support innovation to the point where industry is ready to take it up. The timescale required for this, in our industry, is 5–10 years. We believe that this Institute has a distinctive role, as a centre of long-term engineering expertise for the agri-food industry, in working as research partners with the independent research organisations and with commercial companies. Government schemes such as LINK have an important role in facilitating these partnerships, but the administrative overheads of participating in such schemes must be minimised.

(i) *Industrial application of Government-funded research*

We have been very successful in supporting the agri-food industry by taking our high quality science, funded by BBSRC and MAFF, through via innovation to wealth creation. However to achieve successful technology transfer from Government funded research, there are several prerequisites:

(1) an appropriate balance of basic, strategic and applied research, so that the quality of our applied work for industry customers is supported by sound scientific expertise as well as a knowledge of the customer's needs

(2) stable long-term support for our research teams, essential because of the long timescales required for technology transfer. A 5-10 year period is normally required for innovative research to be transferred to the market

(3) long-term relationships with our industry customers including industry-related organisations, such as levy boards, which fund research, as well as commercial companies.

(ii) *The role of Government Laboratories and independent research and technology organisations*

Like most BBSRC Institutes, SRI has a degree of independence as a Company Limited by Guarantee and a Registered Charity. The last Government carried out two reviews of the role of this and other institutes: the Efficiency Scrutiny of Public Sector Research Establishments (1995), and a Prior Options Review (1996), both concluding that SRI has a distinct role in contributing to the BBSRC's Mission. We believe that this role is to maintain balanced programmes of engineering research with co-ordinated Science Budget, Government and industry funding. In this way, both Government and industry can be sure that there is scientific expertise and innovation underpinning the applied work they are paying for, and ready to help with new problems as they arise.

We greatly value our collaboration with some independent research organisations, such as ADAS, the Campden and Chorleywood Food Research Association, AEA Technology, the Leatherhead Food Research Association, and Morley Research Station. They help us build effective links with industry, and are sources of expertise which is highly focused on industry's needs. These organisations have a different role from our own. They are mainly engaged in consultancy and short term development work, with little basic or strategic research. They avoid innovative topics (such as robotic handling of fragile horticultural products) where major research questions remain unresolved. Our own contribution to UK wealth creation comes from sustained basic and strategic research which is channelled through to industry.

(iii) *The operation of Government schemes designed to promote collaboration in and industrial application of research*

We have had extensive experience of research projects funded through the LINK scheme, and find these a valuable way of encouraging commercial partners to become involved at a relatively early stage of research. They also provide excellent opportunities for our research engineers and scientists to gain experience in multidisciplinary teams including technical staff from industry, biologists, food scientists etc.

However, LINK projects do require a great deal of organisation and time expenditure in setting them up, seeking partners etc. In the early days the complex rules governing LINK led to over-lengthy negotiations, strongly discouraging large commercial companies from taking part, and placing a heavy administrative burden on the research partner. The rules have been simplified and this situation improved. The other point to note about LINK is that many companies prefer to contribute "in-kind", offering equipment and facilities rather than financial support. The UK agricultural engineering industry, in particular, consists mainly of small companies unable to commit funding to research.

(iv) *Intellectual property rights and patenting*

We have no particular comments on this topic. We are satisfied with our own policy; SRI intellectual property is covered by a portfolio agreement with the British Technology Group (BTG), except for contract research when IPR must be negotiated with the customer. BTG advise us whether to seek patent protection on individual inventions; they do this on our behalf only if they anticipate adequate returns from licensing agreements. Of our 34 current patents, 18 are generating income from 16 licensing agreements.

(v) *Provision of finance to support enterprises involved in the application of research and innovation*

We have had problems sustaining funding for research to the point where it is clearly applicable to our commercial customers' needs and ready for transfer to industry funding. Increasingly, MAFF is taking a short-term view of research funding, seeking quick fixes to immediate problems, often triggered by public anxieties or EU legislation; it is unable to sustain strategic funding for topics, such as advanced engineering, which will transform the efficiency of the agri-food industries. For example, MAFF funding for our research on robotic mushroom harvesting and handling was terminated unexpectedly early in 1995 and it has proved very difficult to attract funding to continue the work to a stage where industry is prepared to take it up.

*(vi) The role of the Foresight Programme in fostering networks and identifying priorities*

We welcomed the prominence given to engineering and physical sciences in the generic priorities identified by the original Technology Foresight Steering Group. We believe this has helped establish our role within BBSRC; we emphasise the need for an engineering contribution if innovations in biology are to be put into practice. We have unique specialist expertise in using advanced engineering and information technology in an agri-food context (for example, using image analysis to monitor or grade highly variable biological objects such as pigs or potatoes; using mathematical models to provide decision support for farm management, incorporating ways of dealing with uncertainty about weather or crop response).

(vii), (viii) No comments.

## APPENDIX 62

### Letter to the Clerk of the Committee from Dr Malcolm Skingle, Academic Liaison Manager, Glaxo Wellcome

My colleague, Dr Michael Elves, has informed me that the House of Commons Science Select Committee is seeking evidence on the above topic, and in particular the contributions made by the Engineering and Physical Sciences Research Council.

I would like to draw your attention to a current example, which I think may be of interest to the Committee, where the EPSRC has been particularly responsive to our attempts to expand the science base in the area of combinatorial solid phase synthesis chemistry. This is a new and rapidly developing field of chemistry that is becoming a key tool in the discovery of novel molecules with potential therapeutic activities. We anticipate that within three years research chemists in pharmaceutical companies will need to be competent in the use of high throughput parallel synthesis, solid phase chemistry. They will also need to be conversant with the automation associated with combinatorial chemistry which is required to ensure the creation of novel molecules at a rate of about 10,000 per week.

The emergence of this new field of chemical technology presents a quite unprecedented challenge for both our industry and the science base. It is important that both companies and academic groups are able to enter this, now highly innovative, field for the benefit of the UK's competitiveness. One essential way to meet the challenge is by the provision of the new skills needed by research chemists and ensuring that this is seen as a part of their academic training.

We felt that this new development provided an opportunity to develop partnerships between Industry, Academia and the Research Councils to ensure that we have the expertise needed for future chemical innovation. I therefore discussed this issue at the ABPI where there was a clear consensus that we should approach the EPSRC with a view to developing partnerships and provision of co-funding for this area of research. To date, 10 companies (including three SMEs) have expressed an interest in supporting this initiative and it is likely that others will follow.

Because it can take up to a year to set up a consortium of companies to co-fund this type of initiative we felt it important to move quickly in order that UK plc do not miss opportunities in combinatorial chemistry. Therefore, Glaxo Wellcome initiated discussions with the EPSRC with a view to them co-funding grant proposals to stimulate this area of chemistry. Within two months of opening these discussions with the EPSRC's Chemistry Programme Manager, the Council had agreed to match our funding amounting to £750k over three years and a "Call for Proposals" (enclosed) was placed in the national press. We see this as the first step and other companies will almost certainly follow by providing funding, research training, and, importantly, disseminating "State of the Art" know-how to academics interested in this part of the science base.

Several companies have now agreed, in principle, to provide:

- Advice to universities to develop appropriate lecture programmes and practical demonstrations;
- Funding for equipment to demonstrate key techniques in undergraduate/postgraduate courses;
- Industrial scientists to deliver lectures at targeted universities;
- The opportunity for key academics and their postgraduates to learn new techniques within the company laboratories;
- Funding to support postgraduate students working on solid phase projects.

We feel that the EPSRC has been very receptive to these suggestions, they have reacted in a timely manner, and discussions are now ongoing as to how they may further facilitate this initiative. The Research Council, in responding to our call to develop a new programme in an innovative field of physical science, has shown what is possible within the Research Councils to meet the needs of emerging new areas of science and technology. They should be commended for their expediency and their example in this instance held up for other Research Councils to emulate.

If you require any further information about this interesting new development please do not hesitate to contact me.

*18 September 1998*

## APPENDIX 63

### Memorandum submitted by Smiths Industries plc

A. Introduction

1. This Memorandum presents the views of Smiths Industries plc on the issues to be investigated by the Innovation and Technology Transfer Inquiry. It is written in response to a request from Jessica Mulley, Clerk of the Committee.

B. Summary

2. This Memorandum considers UK government influences on product innovation and success in the aircraft equipment industry. It recommends that the UK government takes steps to ensure level playing fields in the international market, fiscal measures to encourage long term research, and examine how EC funding procedures might be improved. The funding of "demonstrator" programmes is encouraged as a means of speeding transfer of technology to market. Other more detailed recommendations are included in the text, and summarised in section J Conclusions.

C. Successful Innovation in the Aerospace Equipment Industry

3. The Annex gives an overview of how new products are launched for this market. It is intended to set a helpful context for the observations in this memorandum.

D. Application of Government Funded Research

4. In the aerospace equipment industry the main locations for government funded research are academia, government laboratories, and work carried out directly in industrial companies. Academia is a suitable location for pure scientific research. The slightly rarefied atmosphere and continuity provide a good environment for deep investigations frequently on a narrow front. A weakness of research carried out in these

areas is exemplified by the large step in outlook and environment from academia to industry. This means that the process of transferring the technology into a practical application is to some extent hindered by the differences in philosophy of the organisations and their separateness.

5. Government laboratories carry out a large amount of funded work and have access to the fruits of work carried out in industry, where the laboratories are used to oversee the industry spend of Government funds. While the outcome of this work is published, much of the value of this work is still locked into the minds of those who carried out the work and who remain employed in those laboratories. Specifically, there is an additional concern in the aerospace industry now that DERA is being required to operate on a commercial basis. DERA is sometimes perceived by industry as a potential threat or competitor, and this acts to inhibit the transfer of knowledge.

6. Government funded research work carried out within an industrial company can be a very powerful stimulus to the company doing the work. Usually, the intellectual property generated is required to be freely disseminated, and this is done by the issue of reports and briefings. Once again, much of the key knowledge remains in the minds of those who carried out the work and therefore remains most accessible within the company that carried out the research.

### E. Collaborative Research

7. The government frequently operates directly or through other agencies to encourage collaborative research projects involving several companies. This works best where the collaborators have few areas of mutual competition. Within the UK a collaborative project on an airframe structural topic will probably involve British Aerospace Military Division, British Aerospace Airbus, and Westland Helicopters. There are relatively few competitive overlaps between those companies, and the collaboration and exchange of data is likely to be free and full.

8. Where collaborative ventures are attempted in, for example, the avionics industry, the potential collaborators each have many areas of mutual competition. These act as barriers to what otherwise would be obvious collaborations. Clearly, the incentive to overcome these barriers would be strengthened if the normal 50 per cent level of government funding were increased.

### F. Improving Design and Manufacturing Processes

9. Smiths Industries Aerospace is aware of, and has contact with the work funded through the Engineering and Physical Sciences Research Council which is directed at improving industrial processes. A significant percentage of the funding is directed to academic institutions such as the universities at Warwick, Cranfield, and Bath. It is felt that sometimes the directions taken by the academic institutions are influenced by the fact that they are 100 per cent funded. The industrial companies contribute at least half of their own costs, and are therefore inclined to be both more discriminating and to wish to drive to quicker results than the natural academic pace would achieve. Most advanced industrial companies strive to improve all aspects of their business flow and efficiency and consider the details of their operating process to be discriminators and wish to keep these confidential. Thus companies prefer in many instances to engage in a single company process improvement initiative and find difficulty in participating in multi company collaborations where the obvious collaborators are frequently also fierce competitors. It would be valuable for the Committee to seek the views of the EPSRC.

### G. EC Initiatives

10. Over recent years the amount of UK government direct funding to the industry has diminished as EC programmes have become available. It is felt that in many respects the structure of EC initiatives is such as to lead to low efficiencies. A typical EC initiative will involve eight to 10 partners, which implies a significant overhead in programme management and travel costs. As a matter of policy it is usually required that some of the collaborators in the project come from less developed areas, or less capable companies. In the avionic industry where the number of customers is small there is no real need to increase the number of participants, and it is felt that much of the money invested in these weaker partners is not well used. The typical EC project will also require a percentage of collaboration from academic institutions who will receive 100 per cent funding for their contribution. The other partners are presumed to provide 50 per cent of their own funding.

11. Overall, it is felt that the cost effectiveness of EC initiatives is low—particularly for UK participants. Consideration should be given either to rebalancing the funds allocated directly by the UK and those directed via the EC, or to reforming the nature ofthe EC initiatives to place higher priority on industrial effectiveness and less on social issues.

### H. Direction of UK Government Assistance to Aircraft Industry

12. The value of the major airframe and engine manufacturing companies and their contribution to national wealth and export is well recognised by the UK government, and funding is directed accordingly. It is the experience of the companies that supply equipment to the airframe and engine industry that relatively little of this funding and related activity finds its way down to the equipment sector. The UK government are encouraged to recognise the strong direct export achievements of the equipment industry, and direct funds accordingly.

### J. Conclusions

13. Smiths Industries plc through its Aerospace Group, is a successful part of a successful exporting industry. It operates in an international market with intense competition. Some of the foreign competition is effectively supported by its own government. The industry needs UK government support to as far as practical ensure a level playing field in this international competition.

14. In order to grow, the industry needs to launch new products, and to do so needs an environment that encourages steady long term investment in product research, and fiscal measures should be used to support this. Continued support for long term research and the availability of funding for demonstrator programmes would strengthen the speed at which technology transitions into product.

15. The dual role of DERA (as expert advisor to MoD and executor in general of R&D) on behalf of MoD may be an inhibitor to full national exploitation of the knowledge held in their establishments and staff. Organisational and physical separation of the two roles could help break down this barrier to exploitation.

16. The most effective transfer of technology from research to product is within the framework of a single company. In-house research and development needs encouragement. The issue of focus of academic establishments in collaborative programmes needs to be addressed. Some means of adjusting their funding ratios to similar levels to those applying to the industrial partners might help to achieve this. The EPSRC is active in encouraging process improvement, and its views on harnessing the academic inputs and on multi company projects should be sought.

17. EC funded initiatives need to be more closley targeted onto those companies likely to succeed in the market, and the balance of UK government to EC funding should be reviewed. The aircraft equipment industry should receive assistance on a similar basis to the airframe and engine industry.

18. The Aerospace Group of Smiths Industries plc is part of an industrial sector which has had long term success in penetrating world markets. Wise incentives for internal R&D, assistance with technology transfer via demonstrator programmes, and closer focus in the industrial objectives of government funding would increase the nation's share of this international market.

*11 May 1998*

**Annex**

## How Innovation Takes Place in an Aerospace Equipment Company

### A High Technology Industrial Company

1.1 Smiths Industries plc is a FTSE 100 company operating in the engineering sector with a £1 billion turnover. Its activities are approximately equally split amongst the three fields of Medical, Industrial Products, and Aerospace. Approximately 50 per cent of the Company's products are sold in the USA, 25 per cent in the United Kingdom, 20 per cent in Europe, and the balance elsewhere. This Memorandum is written in the context of the Aerospace Group activities.

1.2 The Aerospace Group supplies mainly electronic products to the Civil and Defence Aerospace Industry. Very few of the products are of a consumer nature and the majority are designed specifically for application in each particular aircraft. A high percentage of the products is exported directly to overseas customers. A further fraction is embedded in UK airframes or engines and exported indirectly. Smiths Industries have been successful in growing its turnover and profitability and in penetrating overseas markets. It has received many Queens Awards for both exports and technology, the most recent being in 1998 for Technology for the Electrical Load Management System supplied to the Boeing 777 aircraft.

### Innovation in Smiths Industries Aerospace Group

1.3 Smiths Industries Aerospace sells its products on the basis of performance and price. The Company's need for innovation is in its product design and in its manufacturing processes. The dominant innovation activity is in product design.

1.4 The most successful growths in turnover and market share have been achieved where a new type of product has been brought to market. It is instructive to consider briefly the conditions necessary to "invent" such a product. In order to successfully invent a product it is necessary both to understand the problem to

be solved as well as have the means of solving that problem. Background knowledge of how our industry operates and of the ways in which aircraft are operated form essential background information. The Company engages in research and development. Five per cent or less of such investment is in basic science—areas such as material science, propagation of signals in fibre-optics, and human machine interface. The bulk of the innovation and product development process requires the adaptation and application of knowledge generated in non-Aerospace fields. Examples of this type of knowledge are:

- Silicon integrated circuits—in this field the large purchasing power and development thrust come from the computer and consumer industries. These large spends cause technologies and components to become available which can then be used in other industries.
- Computing architectures—the large expenditure on computer development for general application generates computing architectures for personal computer and other applications which can then be retargeted for aerospace use.
- Computing software tools—tools developed for a wide range of industries are then adapted for use in the aerospace and other specialised industries.

1.5 It can be seen that many of the successful products launched for aerospace application depend on small amounts of specialist basic knowledge obtained from research and the importation of technologies from those industries that, by virtue of their large turnover, drive new generally applicable technologies. Clearly, success depends on the availability of these factors together with the specialist knowledge of customer needs.

### Applying the Knowledge

1.6 No new product will be launched without a willing customer. In cases where innovation has led to a new type of product, customers are frequently reluctant to commit to that product until they have satisfied themselves that the originating organisation can develop the product on time, and that the product will actually perform its intended function. A key step in achieving this acceptance is frequently to build some form of demonstration product on a one off basis, which is crudely representative of the final intended product and demonstrates the availability and operation of the product to the customer. Once the customer has accepted the principles so demonstrated, the supplier and customer commit to a formal product development process.

1.7 The design of this new product for production and delivery is undertaken by some form of engineering project team. This team needs to acquire the technologies which had been previously identified and perhaps included in the demonstrator product. The transfer of technical knowledge into a project team is a real challenge. It cannot be achieved merely by giving members of the team development reports to read. The transfer is best achieved by giving the team direct physical access to the originators of the ideas, and ideally by implanting the originators into the project team for a period. It is apparent that this type of transfer is most easily achieved by in-house training and exchange of staff.

### Enablers of Innovation

1.8 The key needs for rapid and successful product innovation can be extracted from the preceding paragraphs:

- Available in-house knowledge and experience of customer needs and problems (industry know how).
- A selective programme of research into the industry specific, basic, scientific knowledge. This is effectively the seed corn from which the process flows and requires a protected environment to encourage invention. Specifically, continuity of funding enables longer range research to be undertaken.
- A transfer mechanism to ensure the basic scientific knowledge moves from the researchers to the project teams charged with designing new products.
- Training and information exchange mechanisms within the Company to ensure that the technologies becoming available from other industries are assimilated by the product development team.

1.9 Government plays a major role in setting the economic and other parameters which encourage long term basic research and dissemination of knowledge.

### Conditions for Successful Launch of a New Product

1.10 No product can be successfully launched without an available market opportunity. In aerospace the market is truly international, with a relatively small number of airframe customers—principally Boeing, British Aerospace, Airbus, Lockheed Martin and GKN—and the competition is also truly international. Following the announcement of intent to launch a new or modified aircraft the manufacturers will invite interested suppliers to propose equipment for that aircraft. The aircraft manufacturer is interested in equipment that is close to the state of the art, because this usually implies both costs and performance

advantages. He is also interested in low risk development of his aircraft, and therefore is attracted to products which have been shown to be viable. The equipment supplier who has some means of demonstrating the viability of his proposed product is in the strongest position.

1.11 The equipment supplier must also have access to the funds to launch the product. Increasingly in the defence as well as civil market, suppliers are expected to bear the cost of launching the product themselves, and in some cases contribute to the launch costs for the airframe. Overall, the manufacturer of the equipment must have the prospect of a reasonable economic return. To achieve this generally requires that the time from the conception of product to production delivery is kept short, that the manufacturing and design processes are efficient and affordable, and the quality of the design and manufacturing processes be of world class standards. Thus in addition to innovation on the product itself, the equipment company must continue to innovate and refine its internal processes.

## Supplementary Memorandum submitted by Smiths Industries plc

### A. Introduction

1. Smiths Industries plc submitted its views on the issues to be investigated by the Innovation and Technology Transfer Inquiry in a memorandum dated 8 May 1998. Since that date, Smiths Industries has become aware of a threat to one of the budgets through which the Government encourages long term innovation and technology in our industry. This supplementary memorandum expresses Smiths Industries' views on that threat.

### B. Summary

2. Smiths Industries has reviewed the content of its memorandum submitted on 8 May 1998 and does not wish to change its content. A copy of the original memorandum is attached as an Annex. However, it is understood that consideration is being given to eliminating the DTI budget provision for CARAD (Civil Aircraft Research and Demonstration) and Smiths Industries wishes to comment on the impact this would have on innovation and technology transfer. It is the view of Smiths Industries that elimination of the CARAD budget would seriously affect the long term prospects for civil aircraft and equipment development in the UK and we would urge that the budget be retained for this and future years.

### C. CARAD Programme

3. The CARAD programme is managed by the Department of Industry. The objectives of the programme are:

- to help industry be more competitive;
- to make UK industry a more attractive partner in collaborative projects;
- to assist industry in taking a long term view;
- to achieve spin-off from military funding.

4. CARAD focuses on pre-competitive, collaborative, technology acquisition and demonstration. It does not provide support for prototyping or product development.

5. Within Smiths Industries Aerospace the following current research activities benefit from significant DTI CARAD contribution:

#### Flight Deck Concepts

An activity intended to improve the safety of aircraft operation and identify new products that would have a world wide market.

#### Health and Usage Monitoring

This covers a range of technologies which are in the transition from theory to practice and which offer opportunities to increase safety and cost effectiveness, particularly of Helicopter operations.

#### Electrical Power Distribution

Smiths Industries have so far established a lead in both commercial and defence markets, which is now threatened by major foreign competitors. This activity is one of many intended to maintain this international lead.

AVIONICS ARCHITECTURES

Including investigations and demonstrations of more cost-effective concepts of centralised and distributed processing, common software and interconnecting networks and components.

OPTICAL DATABUS

The effective application of optical databuses is a key factor in the economic design of the future integrated avionic systems that will displace existing products in our markets.

6. The budget level for CARAD over several years has been very close to £25M per annum. The major elements of the spend are approximately 40 per cent to DERA (Defence Evaluation and Research Agency), 13 per cent to Universities and 28 per cent to collaborative programmes within industry. The funding through DERA is intended to ensure maximum spin-off from the defence to the civil sector.

7. It is understood that there is a proposal to eliminate CARAD from future budgets for the DTI. This is the only UK Government budget directed at civil aviation research. The proposal will have a significant adverse long term effect on UK industry.

8. Chart 1 (attached)[31] indicates the level of Domestic/Public Authority funding for all Aerospace Research and Technology activities in the EU countries in 1997. The level of public spending in the UK compares badly with that of the other countries with major aerospace activity (notably France and Germany).

9. Smiths Industries would urge that the CARAD budget be retained and that its value be incremented each year roughly in line with the RPI (Retail Price Index). In the longer term a wider ranging review should be undertaken of the level of public support for Aerospace R&T in order to more nearly achieve parity with other EU nations, in line with paragraph 13 of our original memorandum.

*26 January 1999*

## APPENDIX 64

### Memorandum submitted by the Society of British Aerospace Companies (SBAC)

1. INTRODUCTION

1.1 The SBAC is the internationally recognised trade association of the UK aerospace industry and represents the interests of 180 companies.

1.2 Aerospace is one of the UK's remaining world-class manufacturing sectors. The aerospace industry, still largely in UK ownership, is highly successful with sales of £13 billion, and a positive balance of trade of £2.9 billion. The current products and capabilities of UK aerospace have been built on past investments in research and technology, but this national resource is being consumed without adequate renewal. The lack of an adequate bank of high technology will inevitably result in the loss of aerospace capability and capacity. A reversal of this trend requires a strong partnership between Government and industry in promoting science and technology.

2. SUMMARY

2.1 Government funded research is valuable in the pre-product development stage but may not directly influence companies in the development of new products. Technology evolves from basic research through applied research and technology demonstrators into products. Successful products require that all stages be completed. Currently, demonstrators are inadequately funded despite their proven efficacy in reducing project risk and cost.

3. GOVERNMENT FUNDED RESEARCH

3.1 In developing new products, companies will initially consider the following factors, none of which are related directly to Government funded research:

- The needs of customers and the business situation;
- Business strategy;
- The state of competition;
- The effective use of resources within the company; and
- Investment strategy and the balance between long and short term performance.

[31] *Not printed.*

3.2 However, Government funded research may influence the business decision if it has an impact on costs, effectiveness or risk of the development, or if technological advances would not have been otherwise accessible by the company. Government funded research is particularly helpful in the support of technological advances in the pre-product development stage, that is basic research through applied research into large scale technology demonstration. Some of this underpinning work may not, particularly in those industries with relatively long product cycles, be associated with a specific product development decision.

### 4. Government Laboratories

4.1 The Defence Evaluation and Research Agency (DERA) is the main aerospace-related research organisation. Industry's view is that DERA should be a national asset with three key roles as follows:

— Responsible for maintaining an impartial source of advice to MOD;

— Maintenance of capabilities which are essential to the UK's defence which the market will not develop and maintain;

— Developing R&T facilities and technology which can be exploited for wider national benefit, including encouraging dual use technologies. Industry is best placed to exploit these opportunities in the market.

4.2 At present, industry is uncertain about the role of DERA, which appears to be driven by the perceived need to exploit its own facilities and intellectual property as well as objectives of national policy. This lack of clarity can lead to inefficient use of resources because if DERA and industry both operate on a commercial basis, they tend to duplicate facilities and effort rather than sharing them, and the mutually beneficial free flow of information between the two is inhibited by competitive considerations. Industry would like to see a removal of any ambiguity in DERA's role and a recognition by MOD that it is for industry to implement solutions in the market rather than DERA.

### 5. Schemes to Promote Collaboration

5.1 The success of Government schemes designed to promote collaboration in, and industrial application of, research have been marginal in influencing product development. However, past schemes such as LINK have been useful in individual cases, but at £33 million per annum, its scale, when compared with the total R&D spend, is unlikely to have major impact on industry.

### 6. Intellectual Property Rights and Patenting

6.1 Companies generally want to ensure that they have secure IPR in their products and in key technologies that they are associated with.

### 7. Provision of Finance

7.1 The DTI funds civil aerospace programmes through the CARAD scheme. This is currently worth £22 million per annum and has been steadily diminishing over the last few years. Despite this low level of funding compared to our major competitors, CARAD is extremely valuable for its contribution to the promotion of generic research and the links it creates between industry, the research agencies and academia. Without CARAD, the aerospace industry would be seriously disadvantaged when bidding for places on international collaborative projects.

7.2 The UK is strong in research but weak in exploiting the results. In aerospace, the link between research and products is provided by large-scale demonstration of the capability to exploit technology. The National Audit Office (1996) and the House of Commons Trade and Industry Committee (1993) also highlighted the value of demonstrators in reducing costs and risks. One of the key issues identified by *Foresight* was to underline the importance of demonstrators and recommended that the balance between funds directed to basic research and that directed to technology exploitation should be reconsidered. The Foresight Defence and Aerospace Panel reported that the latter receives inadequate Government investment.

### 8. Foresight Programme

8.1 The Foresight Programme has been very effective in fostering networks, identifying priorities and obtaining better value from research funding. The Defence & Aerospace (D&A) Panel has brought together academia, industry and government departments in a way that has not previously occurred. To stimulate demonstrator activity, the Society of British Aerospace Companies (SBAC) created *Foresight Action*—a national programme for aerospace innovation and growth through large-scale technology demonstration. It is designed to exploit Britain's strengths in aerospace and to convert good British science into commercial products.

9. Role of EPSRC

9.1 The aerospace industry is committed to maximising industrial benefits from the EPSRC's Innovative Manufacturing Initiative. For example, the SBAC-led Lean Aerospace Initiative (LAI), which brings together research funders, providers and users in a powerful new structure, could become a model for future relationships. The dual aims of the LAI are to achieve the best wealth creation return on research investment and to establish world class centres of academic excellence in manufacturing processes. The concentration of expertise in centres of excellence has proved successful in other areas where firms have formed close links with selected universities.

9.2 In order to maintain and develop the technology areas and provide robust and effective industry/academia/government links the D&A Panel has presented a proposal to the EPSRC to support the formation of Defence & Aerospace Research Partnerships (DARPs) or Centres of Excellence.

10. Previous Recommendations of Science and Technology Committee

10.1 Operating as it does in a global market, the aerospace industry is acutely aware of the need to be creative, innovative and competitive. In addition to the D&A Panel activity, DARPs, LAI and *Foresight Action* already mentioned, the SBAC also has the following programmes, all of which contribute to the actions recommended in the 1994 report:

- Supply Chain Relationships in Aerospace (SCRIA);
- Human Resources and People Management;
- Engineering and Manufacturing Innovation;
- Business Winning;
- Knowledge Management

10.2 To encourage young people to adopt aerospace as a career, the SBAC has been working with the Royal Aeronautical Society and the Engineering & Marine Training Authority to improve the image of the aerospace industry in a competitive recruitment market. The theme for the SBAC Farnborough International this year will be *Youth in UK Aerospace*.

10.3 Individual companies also have internal programmes to improve competitiveness which are too numerous to mention. Nevertheless, the cumulative effect has been to make UK aerospace the most competitive in Europe.

11. Conclusions

11.1 The aerospace industry depends for its long-term survival on a continuous flow of scientific and technological innovations. While these undoubtedly depend upon the health of a broad-based science base, driven by intellectual curiosity, we believe that industrial priorities should inform academic priorities more directly than they have in the past. There is a need to stimulate a virtuous circle between investment in the science base and wealth creation, for without the latter, public resources available for the former will necessarily shrink.

*March 1998*

**Supplementary Memorandum submitted by the Society of British Aerospace Companies (SBAC)**

1. The memorandum submitted by SBAC in March 1998 remains current in expressing the views and concerns of the Society and the Aerospace industry it represents. However, intervening events, notably the Strategic Defence Review and the outcome of the Comprehensive Spending Review, make it necessary to draw the Committee's attention to a number of areas of concern that have arisen since that time.

2. The Strategic Defence Review has initiated the concept of Smart Procurement, very much supported by Industry. A key factor in successful implementation will be adequate and focused front-ended investment in future defence research and demonstration programmes which we believe is necessary to reverse the current downward trend in MoD's commitment to long term research. The Review also initiated a programme to create a public, private partnership for the future of DERA. It is essential that this recognises the demands of Smart Procurement and removes the uncertainties expressed in our earlier memorandum to the committee on the role of DERA.

3. The outcome of the Comprehensive Spending review has still to be clarified by DTI in respect of the future of the CARAD programme whose importance was stressed in our earlier evidence.

In October we met with the then Secretary of State and expressed our concern noting that even with CARAD at current levels of funding, UK public investment in civil aerospace research has fallen way behind that in France or Germany. We believe that in restructuring international industry this will cause migration of work to the benefit of those nations willing to invest in Aerospace. You may know that concern on this issue has been raised in the House by a number of Members.

*January 1999*

## APPENDIX 65

### Memorandum submitted by St John's Innovation Centre Ltd, Cambridge

St John's Innovation Centre Limited is responding to the Committee's letter of 27 January addressed to Professor Goddard, Master of St John's College, Cambridge.

The St John's Innovation Centre (SJIC) was established by the College in 1987 to manage its Innovation Park, which provides fully serviced accommodation for about 60 small companies, and also to create a supportive environment for early stage knowledge-based businesses in the wider Cambridge area. The Centre also operates a number of schemes on behalf of the Business Link focused on the support for such businesses. In addition, SJIC is accredited as a Science Park by the United Kingdom Science Parks Association and as a European Innovation Centre by the European Business Network. SJIC has recently been invited by the EU to run a Relay Centre. In addition to the tenants of the Innovation Centre, SJIC currently provides advice to about 400 other knowledge-based businesses per annum.

Based on our experience, our view is that the problems in the UK in innovation and technology transfer in the field of engineering and physical sciences apply equally to other areas of technology, and to other parts of Europe. For example the findings of a recent report by Booz-Allan and Hamilton for the Dutch Ministry of Economic Affairs (The constraints to growth in ITC (Information and Communications Technology) in the Netherlands, February 1998) could equally well have been written about the United Kingdom and problems of technology transfer in the area of engineering and physical sciences.

The staff of the Innovation Centre work widely in Europe and although the support services for technology transfer that exist in the Cambridge area are extremely sophisticated in a European context they seem to operate with a minimum of government support compared with those of our neighbours. Government assistance in the UK is mainly based on areas of deprivation rather than opportunity. To take but two examples, the LUST programme operated through Chalmers University of Technology and the SPINNO Programme operated in the Helsinki Metropolitan area are totally government funded on a continuous basis, and are aimed at trying to identify and assist training of early stage knowledge-based business entrepreneurs. Our equivalent, the Anglia Enterprise Network (AEN), is Local Challenge Funded (50 per cent in the first year, 25 per cent in the second year and nil after the third year) and is insufficient, in our experience, properly to support emerging SMEs spinning out of the University and research institutes in the Cambridge area. In the interest of UK plc, we suggest that consideration should be given to a government programme to identify proactively, and support, team building and financial guidance for spin-outs in all technology sectors. The Business Links are not interested in providing this support as they have to cover at least 25 per cent of their costs from income; their target companies are therefore those who employ more than 10 people and who can pay for their services. University industrial liaison officers do not in general have the experience or expertise to help such businesses. They, too, are under-resourced.

As far as the Foresight Programme is concerned, our view is that it has had a very little effect on SMEs in the Cambridge area. There is fair understanding of Foresight amongst academics, government departments and large companies, but SMEs fail to see its relevance to their requirements.

SUMMARY

Based on our experience in the Innovation Centre we do not believe that there is anything particularly special about the problems of engineering and the physical sciences. The lack of professional support that we have described above is general to innovative knowledge-based SMEs and the situation is particularly acute in assisting early stage spin-outs. These problems revolve around management (lack of entrepreneurship and qualified personnel) and the funding to take innovative ideas into the market place.

In the interests of UK plc we would like to see centres of excellence in technology transfer (probably Science Parks) be asked to submit proposals showing how they would best promote technology transfer in their area if they were funded to the extent of, say, an additional £50,000 per year for five years. Perhaps three awards might be made per annum, nationally, based on the quality of these plans. The creation of locally based seed funds such as, in the Cambridge area, Cambridge Research and Innovation Ltd should be encouraged; additional personnel should be made available to them, funded from public sources, where they can demonstrate that they could provide assistance to more companies if they had more assessors. In those locations where it is believed that there is need for seed finance but where such mechanisms do not exist, perhaps the Government should address this market failure, and establish perhaps two pilot projects with funding available of, say £5 million per fund.

*W J Herriot*

*March 1998*

## APPENDIX 66

**Letter to the Clerk of the Committee from Lindsey Simpson, Director, Enterprise and Economic Regeneration, the TEC National Council**

I apologise for the delay in responding to the Committee's request for written evidence from the TEC National Council. I have enclosed a copy of our report "*Promoting and Assisting Innovation in SMEs*[32]" which, while it does not deal specifically with engineering and physical sciences based innovation, does contain what we believe are a number of key lessons which are equally applicable in this area.

In response to the particular points which you make:

1. The Industrial Application of Government Funded Research and the Respective Roles of Government Laboratories and Independent Research and Technology Organisation

I hope you will find that the section on technology transfer on page 6 of our report is helpful in dealing with both these points.

We believe that one of the major barriers in SMEs in particular, is the lack of in-house capability, both technical and managerial, in accessing technology.

A second equally important issue is the ability of universities, laboratories and other organisations involved in technology to support SMEs. The role of the business support intermediary with specific skills relating to technology transfer is the key to overcoming this barrier.

2. Finance

It is very much our view that accessing finance for innovation remains a real barrier in SMEs. This is, however, as much to do with the financial management capabilities of SMEs as with the availability of finance.

3. The Role of the Foresight Programme

We have been particularly impressed by the work carried out by the Manufacturing Panel of the Foresight programme in producing a support tool for intermediaries to help SMEs to engage in foresighting activity. It is through practical applications of the principles of foresighting such as these that the programme can provide most assistance to SMEs, if they are to maximise their capabilities in terms of innovation and taking up technology.

I hope you find this brief response and the enclosed report useful. If you have any further requirements, please let me know.

*23 April 1998*

## APPENDIX 67

**Memorandum submitted by Terrapin Limited**

Introduction

Terrapin Limited has established over the last 50 years a reputation for the design, manufacture and construction of innovative prefabricated buildings. As a result the name "Terrapin" appears as a definition in the Oxford English Dictionary. The origin of the Company, and its early success, was due to the adoption of innovative techniques. Protective patents have always formed part of the Company's attempts to protect its investment into research and development and has found that these can be particularly of value when licensing products to overseas companies. For instance, our Japanese Licensee has been operating under the name of "Nippon Terrapin" for more than 30 years. However, Terrapin is still a private medium sized company and, as such, has limited resources to exploit its advances.

Summary

Our past innovations and use of technology transfer has been recognised and published, for instance, by Martin Pawley in his book entitled *"The Second Machine Age"* where our use of pre-galvanised cold rolled steel in structure and the technology transfer of glass reinforced polyester based freezer truck panels into the construction industry as cladding panels were particularly identified as exemplars.

[32] *Not printed.*

Historically, our R&D department has been supplemented by testing work in Universities with compatible expertise. We have tended in the past to go it alone and try to control and benefit from investments in R&D directly. Currently, we are adopting a different approach to our research and development and are indulging in less "science push".

In the last two years we have encouraged far more Client pull in the development of our products to meet Client's perceived needs. We have also changed our mix in delivering innovative products. For instance, we have been working closely with The Steel Construction Institute and British Steel on new techniques. In contrast with the past, we have encouraged the take up of these techniques within the industry on the basis that rapid market acceptance will deliver earlier benefits to us providing a competitive edge is maintained by us. Our current mix of activities include sponsorship of research through BSRIA; contribution to the Light Steel Sector of The Steel Construction Institute and its R&D programmes. (Many of SCI R&D activities seek and receive Government funding); close co-operation with British Steel and an input to some of its product and market development activities; two specific research projects at Universities and, finally, our own research and development with its limited facilities for simulation and testing but from which further recent patent applications have been generated.

*16 February 1998*

## APPENDIX 68

### Memorandum submitted by The Royal Society

1. The Royal Society welcomes the opportunity to give its views on engineering and physical sciences based innovation. The Society believes that the issues raised are of great importance: it will continue to be active in providing advice to Government and others on this subject.

2. The Society would like to draw attention to the following publications which are of relevance to this inquiry: *Intellectual Property and the Academic Community* (March 1995), *Technology Foresight* (October 1995) and *Realising our Potential Award (ROPA) Scheme* (August 1996).

3. This response has been endorsed by the Council of the Society. It was prepared by a group led by Professor AM Stoneham, and comprising Professor P Hutchinson, Professor JE Midwinter, Professor EP Raynes, Professor JD Rhodes, Dr MJ Stowell and Dr MR Tubbs.

"To enquire into the Manner in which Companies in the Fields of Engineering and Physical Sciences Decide on Developing New products and Processes and the Factors Influencing Their Decisions, with Particular Reference to:

(i) *The industrial application of Government-funded research*

Government funds for research with industrial relevance derive from a wide range of sources and programmes such as the EPSRC, the LINK scheme, Government Research Establishments, the National Health Service, the EU, EUREKA, company teaching schemes and through university collaborations with industry. Key points to note are that:

- relevance is almost impossible to measure on a time scale of one to three years;
- there are other valuable outcomes besides patents or other IPR, such as better-informed decisions regarding product development and commercial strategy, including the identification of ways not to proceed. These outcomes may be particularly valuable for key users, yet not publicly reported;
- the selection of research projects funded by Government may be unadventurous.

We recommend looking at the US scheme of seconding leading academics and industrialists to funding agencies. This has some advantages over traditional UK committee systems, which can be extremely conservative and which may promote incremental rather than innovative research. In the US such strategies have resulted in the better and more adventurous application of Government-funded research as a result of the expertise which is available and the high-level personal contact networks spanning industry and academe.

Collaborative links between industry and university departments, conducting exploratory basic or strategic work relevant to industry, can serve to provide industry with:

- a longer-term, broader and sometimes international window on the subject;
- a route to address questions that industry does not have the time to evaluate itself;
- benefits from wider collaborative groupings to attack relatively non-competitive issues that underpin technology.

(ii) *The respective roles of Government Laboratories and independent research and technology organisations*

The reduction in recent years of Government Laboratories and of some large laboratories in the private sector has eroded important training functions, especially for technicians, where current schemes are inadequate. We feel that this has had a significant effect on the small- and medium-size technology-based companies (technology-based at all levels of sophistication) which tend to grow around such large laboratories. On-the-job training at Government Laboratories has been important for many sectors of the research community, including the academic sector, and this gap will be felt. This training role is additional to the solid case which can be made for the roles of Government Laboratories in conducting research for reasons of national security, as standards laboratories, as hosts for large, expensive kit, as hosts for missions, or where efficiency of resource utilisation means that work can not be done elsewhere.

Government Laboratories have traditionally provided stability to conduct research projects of longer duration. The obvious danger is that such laboratories can become fossilised. In this respect it is worth considering the Japanese model, where vitality is fostered by Government Laboratories acting as hosts for projects, each project having a maximum period of funding, usually five years, followed by bids for funds for new projects in open competition.

The independent research and technology organisations (IRTOs) have a role to play as contract research organisations providing specialist skills "on demand" for those organisations that cannot justify the cost having them in-house. IRTOs also have an important role to play in short and medium-term development work, including confidential pre-contract R&D and contract work for specific customers or multi-client groups. Furthermore, IRTOs have a role in providing their members with information.

The Government's role of "informed customer" is less effective than in some other countries, and would benefit from more secondments of leading academics and industrialists. Such secondments are common in the USA.

(iii) *The operation of Government schemes designed to promote collaboration in industrial application of research*

One very successful scheme in promoting collaboration is the CASE scheme which should continue to be given a high priority and should be expanded. First, the "Company CASE" scheme works well, in that the company is able to place the award at a university chosen by the company. Second, given the international nature of UK industry, there should be a broadening of the scheme to include foreign students:

(a) EU nationals, who should qualify for maintenance grants just as UK students do; and

(b) foreign students sponsored by multinationals with interests in the UK.

In both cases, the dividends would eventually flow back to the UK.

It is intolerable that Government schemes for funding collaborative research on occasion generate expectations greatly in excess of the resources available. This leads to needless waste and frustration for those applying. Funding schemes must provide potential applicants with as much information as possible on the criteria for eligibility and the likelihood of a proposal being funded. Such information is of vital importance so that potential applicants can make soundly based decisions on whether to invest resources in developing an application. These resources can be very considerable, especially in the case of collaborative proposals.

In all the schemes care should be taken to ensure that the rules do not create unnecessary problems. Generally, processes need to be more transparent, more stable, and the amount of paperwork reduced.

We also believe that the principle of Treasury attribution is hindering UK efforts to collaborate, especially in competition with Germany. We recommend looking at the German model, which provides extra support to a reasonable fraction of the best of the successful EU projects.

Tax incentives to industry could also serve to promote the uptake of the results of industrial and academic collaborations. We support enhanced tax relief for companies supporting teaching or research in, or in collaboration with, an academic institution.

(iv) *Intellectual property rights and patenting*

In some emerging areas of research some unforeseen problems are emerging concerning intellectual property. These include new types of IPR, such as computer-generated information and simulated results.

Some universities, particularly those that do not have a major commitment to research, may have problems as owners of IPR; for example, they may not be able to exploit it or protect it properly through expensive litigation. They should be encouraged either to leave the IPR in the ownership of the individuals who generated it and/or the bodies that funded it, or else to aid its transfer as soon as is practicable to a body which could exploit it. IPR arrangements should provide incentives for individuals to collaborate with industry and set up spin-off companies.

IPR agreements must allow university invention to lead to a reward, but the reward and demands must be realistic. A clear distinction must be made between the science content and its application; exploiting firms have a responsibility not to obstruct other uses of the science content.

The group was somewhat concerned that some of the existing schemes for deciding who receives the rewards arising from innovation may not be well conceived in that they do not always benefit the intended recipients. In particular, there is a low level of financial reward to individual inventors in the UK. This can inhibit their commitment to exploit their inventions. Many universities provide a good reward scheme, but Government service and industry have a problem with poor or non-existent schemes; in other words, section 40 of the 1977 Patent Act does not work. Inventors in other countries can be better off.

(v) *The provision of finance to support enterprises involved in the application of research and invention*

One model which we support strongly is that of US government contracts awarded in Silicon Valley. These require that 25 per cent of the value of such contracts be sub-contracted to other companies at arms length. If this is not done then the amount is recovered dollar for dollar by the US government. This system has allowed many smaller companies to expand.

The venture capital market, trusts and Enterprise Investment Schemes could be made more attractive by increasing the allowed investment amount per individual. A case can be made for more tax incentives to encourage investors to become involved in more speculative ventures. The capital gains relief roll-over for manufacturing firms provides distinct advantages. In the US there is a culture of individual patrons who are prepared to invest in speculative ventures. The same is less true of the UK, and steps should be investigated to encourage such patrons to invest.

(vi) *The role of the Foresight Programme in fostering networks and identifying priorities*

The Society's views on Foresight are set out in the attached document[33].

We have some doubt that Foresight has had any real significant impact on the longer-term priorities of its main target audiences. We are concerned that the Research Councils claim that Foresight has had such impact. Our concern stems from the now dated conclusions of the exercise and from their apparent generality. One major problem with the Foresight programme was that the Steering Committee set its own priorities over and above those of the 15 individual Panels. Consequently, some of the ranked criteria of the Steering Group may be neither relevant nor appropriate. This is of special concern in that the Research Councils have to pay attention to the priorities of the Steering Committee.

We believe that the Foresight programme was a good idea that was ineffectively run. Its main benefit has been some fostering of networks. There have been secondary benefits, for example that attention has been drawn to research areas which were less evident, such as the food and drink industry.

Some problems arose because the process was rushed to accommodate political deadlines. This diminished the value of the exercise. Furthermore, the Treasury and other Government departments need to be seen to be involved in implementing the Foresight recommendations if the Foresight Initiative is to work effectively and have credibility with industry.

(vii) *The role of the Engineering and Physical Sciences Research Council in fostering technology transfer*

Since the EPSRC confines its funding to the academic sector with minimal exceptions, its role must be to promote research and training for research in this sector. The EPSRC itself does not have the capability for technology transfer. Its role is the encouragement of collaboration and cultural transfer; here, the CASE scheme is an important catalyst.

The EPSRC's remit is too nationally inward looking and UK focused. It must be noted that UK companies are not wholly dependent on the UK science base for their technologies.

The EPSRC also has a role in telling industry about the successes which have come from work which they have funded. EPSRC could for example demonstrate how work undertaken five to 10 years ago has contributed to current successes.

The Interdisciplinary Research Centres have had mixed success. The best of them offer examples which could be repeated. Such centres could be funded on a five year basis with the objective of providing a training focus and subsequent dissemination of knowledge into industry. We have suggested above roles for Government Laboratories and IRTOs as hosts for projects on a similar scale.

There is also a need to ensure that the individual rather than the project is supported, since present committee-based procedures can favour incremental research.

[33] *Not printed.*

(viii) *Progress made towards implementing those recommendations of the Science and Technology Committee in the previous Parliament in their report on The Routes Through Which the Science Base is translated into Innovative and Competitive Technology*[34] *relevant to fields of engineering and physical sciences*

The statements in the previous report are largely qualitative and, since many of the recommendations were not specific or time constrained, it makes appropriate action problematic and progress difficult to measure. Our impression is that not much has changed markedly for the better, with the possible exception of Inward Investment (paragraph 335). Some other areas have clearly got much worse such as the continuing rundown of the academic capital base and reward structure. We urge the present inquiry to identify a number of practical steps to improve innovation in industry and commerce, and that all its recommendations be clearly focused on specific named communities.

*12 March 1998*

## APPENDIX 69

### Memorandum submitted by The Royal Society of Edinburgh

The RSE is pleased to submit the following observations relating to "the manner in which companies in the fields of engineering and physical sciences decide on developing new products and processes".

The RSE in Scotland's premier learned society, comprising Fellows elected on the basis of their distinction, from the full range of academic disciplines, and from industry, commerce and the professions. This response has been compiled with the assistance of a number of Fellows who have an active interest in engineering and science-based innovation.

The key overriding factor which leads companies to develop new products and processes is the existing, or about to be created, market opportunities which drive the innovative cycle. Some of the technologies and processes result from the application of the Science Base which is developed through Government-funded research. The RSE, in conjunction with Scottish Enterprise, analysed the current constraints in the process of commercialising the Science Base and has developed a strategy for Scotland documented in the publication "Technology Ventures—Commercialising Scotland's Science and Technology" (hereafter referred to as "TV") copies of which are enclosed with this response[35].

Government funded research either in universities or national laboratories should target long range basic research objectives to create the pool of science and technology which can be harvested by commercial companies to meet market demands. The USA has been successful in using government funding to maintain technical leadership in for example microprocessors, telecommunications and software that has seen the growth of Intel, Cisco, Microsoft, Ciena and other industrial giants with capitalisation of many billions of dollars.

Referring to the particular influences addressed by your enquiry, we have the following additional comments.

(i) *The industrial application of Government-funded research*

It is essential that mechanisms for this are improved. One might argue that it is wasting the research effort if adequate resources are not brought to bear on the exploitation process. The concepts contained in the White Paper "Realising our Potential" are fully endorsed. See also the strategic initiatives in "TV".

(ii) *The respective roles of Government Laboratories and independent research and technology organisations*

Government laboratories can provide fertile support environments for exploitation through independent companies. The potential role in this aspect could be developed.

(iii) *The operation of Government schemes designed to promote collaboration in and industrial application of research*

Schemes such as LINK which has been recently expanded to SMEs are considered worthwhile and should be expanded and freed from the restrictions of special programmes where funding is limited. The SMART and SPUR schemes are considered very helpful to small companies but are too limited a scale to be effective on their own. Consideration should be given to introducing a scheme along the lines of US Small Business Investment Club (SBIC) investment mechanism. The re-introduction of the Pre-Production Order Development Scheme is also recommended. Teaching Companies are successful in transferring technologies

[34] First Report, Session 1993–94 (HC 74).
[35] *Not printed.*

into "lower" technology companies but are less relevant to high technology SMEs which are based on leading edge technologies.

Government assistance to spin-out companies should be considered. Reference is made to the Royal Academy of Engineering placement scheme and the RSE Enterprise Fellowship Scheme aimed at commercialising good research.

(iv) *Intellectual property rights and patenting*

Intellectual property whether patented or not is the cornerstone of companies in the Information Age yet it is not recognised formally in a company's assets. The Government is invited to consider this in its review of Company Law and related practices.

Greater awareness of the value of IP across society is required and new initiatives to promote its importance should be instigated. The cost of patenting and more importantly defending patents is prohibitive for SMEs and even University groups. A central contracting organisation operating on a commercial basis should be explored. We are aware of a specific initiative in Scotland relating to semiconductor IP which is in development at present.

The question of ownership of Government's publicly funded IP should be addressed to ensure widespread availability to industry.

(v) *The provision of finance to support enterprises involved in the application of research and innovation*

Enterprises concerned with the application of research, often referred to as Institutes within the HEI environment, have played an important part in exploitation of the science base. Funding for these organisations has come mainly from charitable sources. The importance of Institutes is the focus they provide on exploitation of new product and process ideas in association with the pure research of academic departments. The dynamic provided by the co-location is important and is not achieved by central government funded laboratories. The effectiveness of such organisations could be significantly enhanced through developing partnerships of charities with direct government funding.

The early support of High Tech spin out companies, and other High Tech start ups could be improved from the private sector through the introduction of a more favourable tax regime for investors which eliminates capital gains.

(vi) *The role of the Foresight Programme in fostering networks and identifying priorities*

We have reservations about the effectiveness of Foresight although the emphasis on exploitation of research is welcomed. In spite of the acknowledged difficulties, a greater focus on a few key growth industries where our science base can be exploited is suggested. This approach should be complemented by a non specific funding programme to support "blue sky" research.

(vii) *The role of the Engineering and Physical Sciences Research Council in fostering technology transfer*

An effective reward system is necessary to improve technology transfer. Recognition of commercialisation of research should have a higher priority in research councils and funding Government Departments. In Scotland the SHEFC and the Scottish Office should address this issue.

(viii) *Progress made towards implementing those recommendations of the Science and Technology Committee in the previous Parliament in their report on The Routes Through Which the Science Base is Translated into Innovative and Competitive Technology relevant to the fields of engineering and physical sciences.*

We have no specific comment to make on this issue although a number of the foregoing points should indicate where further progress is needed.

*March 1998*

## APPENDIX 70

### Memorandum submitted by The Welding Institute

1. The Welding Institute (business name—TWI)

The Welding Institute is a 6,500 strong Professional Engineering Institution and Learned Society. It is also a large Research and Technology Organisation employing 425 staff, the core business being materials joining. Consulting, contract research, technology transfer and information services are offered worldwide together with training, examinations and certification. It is one of the largest organisations in its field in the world.

## 2. The Industrial Application of Government-Funded Research

A company will develop new products and processes if the management philosophy is one of continuous improvement and change *and* it constantly seeks and is made aware of best practice and new technology opportunities.

Government-funded research should have the following aims:

(i) Create the climate requiring continuous change in companies;

(ii) Help spread best practice within and across industry sectors;

(iii) Assist training of industry staff in enabling technologies;

(iv) Nurture the science base to help create ideas for new technologies;

(v) Nurture the science base to provide trained graduates for employment in industry;

(vi) Create testing standards and accelerate the development of standards for new materials, processes and performance so as to provide confidence to industry to take up new technologies.

## 3. The Respective Roles of Government Laboratories and Independent Research and Technology Organisations

Government Laboratories in the Engineering and Physical Sciences area have a key role in the development of testing standards for materials (new and old) and processes. This should be their sole remit.

Those Government Laboratories which receive a high percentage of their funding from the State represent unfair subsidised competition to the independent RTO network which generally receives a much lower percentage of total funding from public sources.

The independent RTOs are intermediate between Government Laboratories and Universities on the one hand and industry. The RTO role is to draw on the knowledge and information from the former, innovate and add value, and trade with industry. The value added by RTOs will include adaptation of fundamental research, appropriate technology development and the use of the many technology transfer mechanisms needed to embed the technology in industry. The Welding Institute's model for the total innovation cycle is shown in Appendix 1.

In our view RTOs serve industry most effectively by having the knowledge base of their staff refreshed by a corporate research programme of significant size and by constantly demonstrating new technology to companies. Innovation in RTOs is high and is fed by daily interaction with industry on a world scale.

## 4. The Operation of Government Schemes Designed to Promote Collaboration In and Industrial Application of Research

(i) The Government principle of supporting collaborative R&D programmes at the 50 per cent level is satisfactory in requiring and showing industry's commitment. However, lower levels of support are not attractive to R&D producers because of the high cost of proposal preparation and the low probability of winning a contract in the bid process, many calls being oversubscribed.

The route forward is for most programme bid procedures to become two stage (an outline proposal followed by the full proposal if the outline is accepted). The EC runs some programmes in which it funds the preparation of the outline proposal and the formation of the consortium, eg CRAFT. A particular problem in organising collaborative projects involving SMEs is that during the timescale of the bid process which can be 3–12 months, it is common for SMEs to withdraw, putting the proposal and group at risk. Mechanisms for speeding up the bidding and approval process of Government programmes must be sought continually.

(ii) Government needs to consider programmes for accelerating the training of engineers in certain key enabling technologies. For example, in our field, Germany provides subsidies to industry for training of engineers on welding and joining and in robotics. The UK has only 200 degree level engineers with welding engineering diplomas, whereas Germany has 6,000, a direct result of the German subsidy. Robot technology is a key area for attention and for more focus in the UK. Germany has 70 robots per 10,000 manufacturing employees. Japan 350 per 10,000 and the UK only 20 per 10,000.

We would also signal that the UK is three years behind Germany in the application of lasers in manufacturing. This is very worrying and needs a concerted Government/industry campaign to help us catch up. The economic benefits of lasers are enormous in manufacturing.

(iii) Government, through the Research Councils, should force more inter-departmental working in single Universities and more inter-University working. The walls between departments are still too strong.

### 5. The Provision of Finance to Support Enterprises Involved in the Application of Research and Innovation

Finance to support enterprises in the application phase should be dominantly from private sources, but Government can assist in the following areas:

(i) Most SMEs need help in the transfer of knowledge of new processes, materials, etc. The knowledge providers, eg independent RTOs, cannot offer this service because SMEs will not pay commercial rates. This was the conclusion of a recent Welding Institute programme "Joining Forces"; part funded by the DTI. Government subsidy, locally or nationally, is one method of ensuring that SMEs receive support from those who can help.

(ii) A new approach to be fostered by Government is the provision of technical knowledge and data to industry through electronic commerce. The Internet will increasingly allow large companies and SMEs to access relevant data and information from key providers more cheaply and efficiently than hitherto. New Internet products, which are "intelligent", will rapidly access the right knowledge at the right time for users. Government support is needed to develop these new products by assisting in the organising and input of knowledge into these Internet products.

The Welding Institute, with BT, has developed a prototype, JoinIT™, which can be cloned for other technologies.

(iii) The Government's LINK concept for supporting precompetitive research is good. However, there are too few programmes in the manufacturing area in our view, and the UK is falling well behind other European countries in many aspects of manufacturing.

(iv) Government support for the preparation of engineering standards is weak compared to other European Countries. Companies will apply research and innovation more readily if the appropriate materials, testing and performance standards are in place. The wider use of plastics composites is currently held back for this reason. The Government role should be to accelerate the creation of such standards, including any necessary pre-normative experimental work.

### 6. The Role of the Foresight Programme in Fostering Networks and Identifying Priorities

The Foresight Programme has a pivotal role in fostering networks. The Professional Engineering Institutions (PEIs) are the permanent infrastructure which OST should encourage in the Foresight process, but OST must force inter-Institutional working in this respect. Networks could be funded by OST at a "meetings" only level to encourage new ones to form and a wider UK participation, following the recent EC model on technical networks.

Priorities should be determined at the highest taxonomy level by Foresight panels, but at the lower levels by the PEIs. The horizon should be 5–10 years for the most part; not 10–20 years.

### 7. The Role of the Engineering and Physical Sciences Research Council in Fostering Technology Transfer

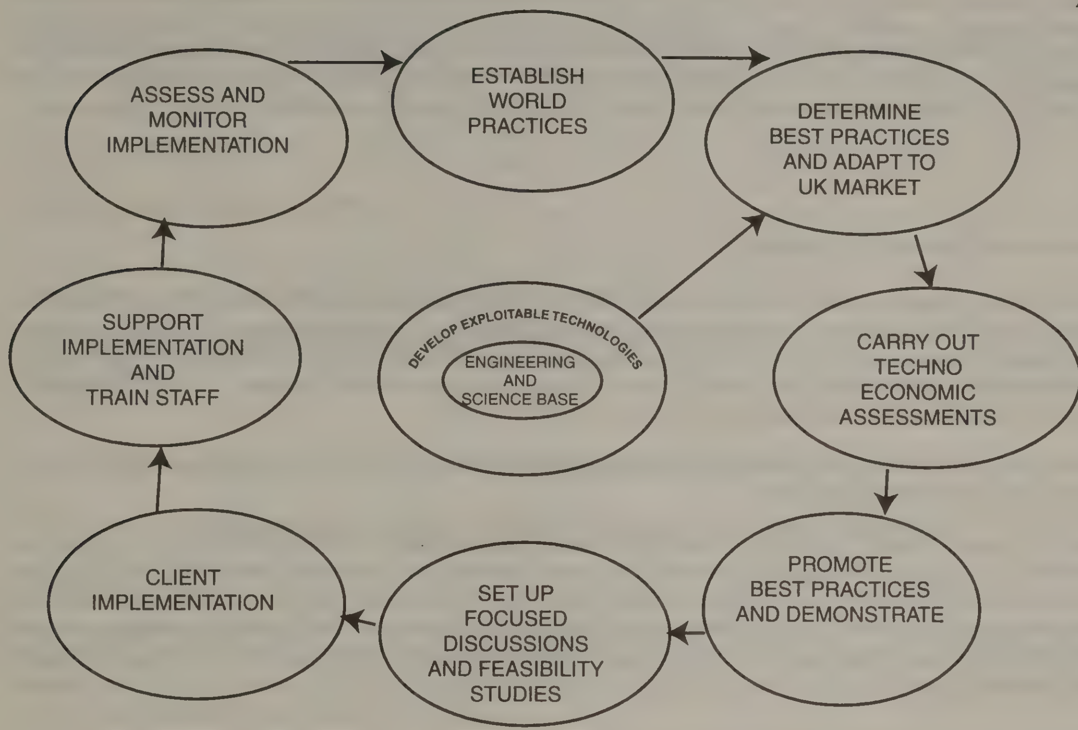
EPSRC should concentrate on three main areas for technology transfer improvement:

(i) More movement of trained people into industry. The Teaching Company Scheme is excellent in this regard, although The Welding Institute's experience is that the quality of the graduates applying for TCS posts is not particularly high. This may be a local problem, but is worrying.

(ii) More and better links should be made to intermediate organisations, eg RTOs, who have a wider knowledge of the industry sectors and market opportunities, and who currently win, annually, significantly more contracts from industry than all the Universities in the UK. Funding to encourage the more successful RTOs to participate in the process should be made available.

(iii) More attention is required on the output of the research contracts that EPSRC funds. The quality of contract deliverables in final reports is very patchy in our experience, and a tighter system of monitoring output could identify more clearly the technology transfer opportunities.

**Annex**




**Materials Joining Technology
Cycle of Improvement**

## APPENDIX 71

### Memorandum submitted by UK Science Park Association

The UK Science Park Association (UKSPA) welcomes the opportunity to submit a memorandum, because of its role in encouraging the creation of environments for growing technology-based businesses, each park working in formal and operational partnership with an associated university, research institute or corporate centre of technology. There are now 50 member parks in the UK, housing some 1,500 such SME, which employ about 25,000, 60 per cent of whom are graduate scientists or engineers.

#### Summary

There is progress in the areas of the Inquiry, but a lack of support specific to the development of technology-based companies beyond the research stage, including establishing management teams and constructing business plans.

The SMART scheme is good, and we would be glad to co-operate in assisting follow-up.

Intellectual property matters are better understood today, but there is a need for more non-legal licensing expertise.

"Exploitation after SMART" is the key point we wish to emphasise. These subsequent stages are vital and a major gap exists.

We suggest a fund might be established, not for investment, but to support commercial assessments of good projects.

#### Memorandum

1. *The industrial application of Government-funded research*

The UK science park movement concentrates efforts on innovative SME with high growth potential. These include some 350 spin-offs from universities and a large number from industry.

The problem we perceive is the lack of support specific to the development of technology-based companies. The need is to go beyond the "proof of principle" stage, to the point of developing good management teams and realistic business plans to attract investment. Present support mechanisms do not properly address this. BusinessLinks, for instance, do not regard this area as a priority and generally do not have the specialised skills required. This problem applies to companies with high growth-potential in all areas of technology.

2. *Operation of Government schemes*

The SMART scheme is good and we welcome the new multiple annual entry. Science parks house and support many SMART winners, so we have the opportunity to follow their progress. Do those on science parks fare any better because of the environment and services provided? If so, it could assist the progress of future winners and would help focus park directors in their task of providing support. We would be glad to co-operate in eliciting such information and in subsequent action.

EPSRC support for technology transfer has been effective through the Teaching Company Scheme and the Innovative Manufacturing Initiative.

The DTI Small Firms Unit is now focusing on corporate venturing. This is relevant to all parks, but particularly to those specialising in supporting spin-offs from existing industry. Might efforts be made to encourage SMART winners and others to seek help from relevant larger firms? If the technology and/or market matches, it could help get commercial skills and finance into the SME, with the larger company supporting a new development in a market or technology it is familiar with, together with the possibility of financial gain.

3. *Intellectual property (IP)*

IP is better understood today by academics and researchers, but clarity of ownership is still an issue for the investor. There is also a need for more non-legal licensing expertise. The most accessible advice to entrepreneurs at present is from lawyers; although the legal advice is good, there is rarely any attempt to ask whether patenting (and the consequent cost and disclosure required) is the correct commercial course to take.

We are also aware that universities can be unwilling to licence IP to new start-ups, but are prepared to do deals with larger companies. There are instances where novel technology is being inhibited from exploitation by those responsible for managing a university's IP.

4. *Finance to support enterprises involved in the application of research and innovation*

This is still a problem but the situation is slowly improving. It is now possible to find sources of initial funding through SMART and other, often local, schemes to support initial "proof of concept" or "proof of market" programmes. The difficulty appears at the next stage.

The science park movement will continue to address this need. There is increasing recognition of the value of locating promising new start-ups on science parks, most of which include a business incubator and offer an environment and services which can facilitate growth. Indeed, we have direct evidence that the clustering of companies in science parks can attract venture funding and the long-term interest of investors.

"Exploitation after SMART" is the key point we wish to emphasise. These subsequent stages are vital, but constitute the major gap in support available. The Government believes that help at the pre-competitive stage should be their main input, and its support stops well short of the point where commercial exploitation can be commenced; whereas commercial investors regard projects at this stage as unnecessarily risky. Thus, many projects fail at this point. Some, of course, deserve to fail; but a significant number of good, exploitable ideas either fail completely or progress at a snail's pace.

Would a fund, not for investment, but to support commercial assessments of such projects be worth considering? Venture capitalists, when questioned on their attitude to this gap, point out that undertaking assessment of a project seeking £100,000 is as costly as one requiring £5,000,000. Support for this process, perhaps involving the input of experienced science park directors with their parks acting as foci or centres of excellence, might be a way of reducing the number of projects which fail at this stage. The UKSPA would be pleased to discuss this possibility.

5. *The role of Foresight*

Foresight is regarded as a successful programme, but knowledge of Foresight amongst SME is very low. If they know about it in general, its relevance to them is not apparent.

6. *The role of the EPSRC*

UKSPA has no specific comments.

7. *Implementation of recommendations of the Science and Technology Committee*

The comments in the Memorandum as a whole should be sufficient.

*1 March 1998*

## APPENDIX 72

### Memorandum submitted by Unilever Research, Port Sunlight Laboratory

1. INTRODUCTION

1.1 Unilever is a multinational company with approximately 200 consumer goods companies world-wide. Unilever's product areas are "Foods" and "Home and Personal Care" (specifically Laundry, Fabric Care, Household Cleaning, Personal Wash, Hair Care, Oral, Deodorants and Skin) which are supported by active research programmes in five major laboratories:

Port Sunlight (UK), Colworth (UK), Edgewater (USA), Vlaardingen (NL) and Bombay (India).

1.2 The Port Sunlight research programme exclusively supports the Home and Personal Care product category. Over the past five years, Unilever has increased its expenditure on external research from three to 12 per cent of its total research expenditure. Unilever has also adopted a policy of focusing on fewer, bigger research projects.

2. SUMMARY

2.1 Unilever's R&D activities are first and foremost consumer driven, hence decisions to develop new products depend on consumer need as well as the availability of appropriate technology.

2.2 A strong science base is critical in order for Unilever to deliver products that effectively meet consumer needs. As such the continued integration of Government funded research into our long term research programme is extremely important to Unilever's continued growth, both in the UK and abroad.

2.3 A strong Government science base, which is aware of global leading-edge capability, would provide an important entry to wherever the science was available when responding to our scientific problems.

2.4 It would be desirable, but not easy, to establish a simple cost-benefit ratio for Government funded research.

2.5 Government funded research plays a major role in developing novel measurement and modelling techniques and less in terms of developing new product technology.

2.6 We propose the Government rationalise its existing schemes to promote industrial application of research.

2.7 It is too early to say what impact the Foresight Programme has had, however Unilever recognises its important long term potential.

2.8 The funding of fundamental blue-sky research by the Research Councils should not be reduced. We believe there is scope to make the technology transfer activities more efficient.

3. UNILEVER'S NEW PRODUCT DEVELOPMENT (INNOVATION) PROCESS

3.1 Unilever operates a single common global Innovation Process Management (IPM) which embraces all brand innovation activities in Unilever's operating companies. It also includes the whole of Unilever's Corporate Category research programme, such as Hair Care, Laundry, Yellow Fats, Beverages etc, which is funded by the business and found in business led projects.

3.2 Cross-category and non-category specific research projects, known as Corporate Research and Engineering Fund (CREF) projects, although not directly business led, are consumer/business driven.

## 4. Factors Influencing on New Product Decisions in Unilever

4.1 The main factor influencing the decision whether or not to agree to embark on a new project in Unilever is that a real consumer need exists for the proposed product. The second consideration is whether or not the project is consistent with the agreed business strategy.

4.2 Assuming the project meet the above criteria then the third factor considered is how the project could actually be carried out, including the possible technology options if relevant.

4.3 The key to successful innovation is the concept of "differentness" as perceived by the consumer. Experience within Unilever has shown that if a new product is different it may succeed, if it isn't it won't. Examples of Unilever products which have been successful in this regard are CK1, Magnum, Organics and Solero.

4.4 Being different however does not automatically imply increased technical complexity, that is to say, the consumer buys a brand and not a bottle of technology.

## 5. Unilever and Government Funded Research

5.1. Although it is not the key influence in the decision making process, a strong science base (including extensive contacts with both Government and academic research institutions) is vital for Unilever in terms of facilitating the implementation of our consumer driven innovation programme. In this regard, Government funded research is a fully integrated part of Unilever's long term strategy as we strive to find ever more effective ways of delivering the physical reality of attractive consumer concepts.

5.2 Despite acknowledging its importance, it is not easy to demonstrate a simple one to one correspondence between a piece of Government funded research and its exploitation in the market.

5.3 Obviously, a simple method of arriving at a cost benefit ratio would be highly desirable. However, in our view it is easier to quantify the costs associated with a piece of research while a measurement of the benefit over a number of years is much harder. There is an additional problem of deciding on the number of years over which the benefit can be said to accrue.

5.4 In the view of the Category Research Managers at Port Sunlight, it is extremely rare for a piece of technology resulting directly from Government funded research to be applied in a product. Instead the key areas of Government funded research with a high impact on Unilever's research programme are in scientific skills such as novel measurement and modelling techniques and methodology to develop new technologies and product claims.

5.5 An illustrative example of this is Unilever's collaboration with Dr Terence Kealey at Addenbrooks Hospital, Cambridge. Dr Kealey is a world expert in the field of hair growth. Unilever was able to take the intellectual property of understanding the mechanism of hair growth to support the launch of the highly successful Organics Hair Care brand. Dr Kealey's main contribution to this was a key measurement technique, in the context of the fundamental biological processes involved, which supported the claims made by the product.

5.6 There is no formal process for identifying Government funded projects of potential interest. Collaborations are generally initiated on the basis of contacts made by individual scientist or as the result of papers presented at conferences, meetings etc. Since most Unilever Port Sunlight scientists will attend at least one conference per year, it is estimated that Unilever is made aware of 80% or more of Government funded activities of relevance.

## 6. Unilever and Government Laboratories and Independent Research and Technology Organisations

6.1 We believe that it is most important that we establish an effective role for the independent research organisations in a way which compliments the activities of Government Laboratories and Universities. It is important to avoid any damaging competitive activity when rival organisations do not have a level playing field.

## 7. Unilever and Government Schemes

7.1 We believe there is scope for rationalisation of the existing schemes to give greater clarity for industry and systems which have a faster response. We should also develop processes which ensure that time is not wasted by industry and Universities when the chance of a proposal's success may well be less than 10 to one.

7.2 Any rationalisation must ensure greater opportunities (than at present) for Small/Medium Enterprises.

8. Patents and Intellectual Property Rights

8.1 One of the key IPM tools used by Unilever is the Consumer Technology Matrix (CTM). This is used to plot the level of enabling technology (ie how radical is it?) used in a product against how the consumer perceives such a product. Almost by definition, projects involving radical or next generation technology (to bring a step change to the market) are viewed as longer term and more strategic than those involving base technology (used in day to day brand maintenance). This is a use of IP as a planning and decision-making factor.

8.2 The benefits to Unilever if we are able properly to protect our technology are increased margins and slower entry to the market by competitors. Effective patent protection is therefore critical to Unilever's continued growth, both in the UK and abroad. Again, we are apprehensive that the Commission's Green Paper on the Community Patent, on which we have submitted detailed submissions through other channels, will result in additional expense and complication for proprietors and will add to uncertainties in litigation.

9. Unilever and the Foresight Programme

9.1 Unilever has participated in the Government Foresight programme and used it to develop a longer term vision of our scientific research strategy. However, it is generally felt that it is too early to judge the impact of this on the output from the category research programme. However, the value of such activity is recognised as having long term value and significance for Unilever and it is important that we build upon the good start for Foresight.

10. Unilever and the role of the Research Councils

10.1 It is vital to get the balance right in the Research Councils' programmes between funding of fundamental research and its technology transfer activity. We are concerned that the fundamental blue skies programmes must not be reduced too much. However, there is scope to make the technology transfer more efficient, rather than spending more money on it.

*27 March 1998*

## APPENDIX 73

### Memorandum submitted by the University of Warwick Science Park

Introduction

The University of Warwick Science Park is mainly concerned with assisting the start up and development of technology based SMEs. This includes assistance with technology transfer with the University of Warwick and a range of measures designed to improve the growth prospects of our client SMEs. The comments that follow are based on 15 years of experience in working in this field. We are less concerned with the relationships of larger companies and the way that they interact with the University.

Technology Based SMEs

Much of the character of the new technology based firms (NTBFs) have been researched by Westhead and Storey in the HMSO document "An Assessment of Firms located on and off Science Parks in the United Kingdom". We generally concur with the results of this extensive survey and it provides a good background to the remarks which follow.

There is a misconception amongst many that NTBFs conduct high levels of R&D. This is generally not true. A few do, but these are the minority. For most NTBFs in the early stages of development up to say £0.5 million turnover, their regular commitment to R&D may be a few per cent of turnover. This may mean R&D budgets of £25–100,000 pa. Most of this they will expect to carry out in-house in order to maintain control over development time scales. Thus, the amount of resource available for funding extra mural R&D at a University or Government Research Laboratory tends to be modest in terms of the type of budgets that Universities are interested in.

NTBFs at Warwick and throughout the UK may be classed into two types:

- Product led businesses (both hardware and standard software products)
- Knowledge or service led businesses (including bespoke software development).

The latter category outnumbers the former by about 3:1.

It is the product led businesses which have the greatest need for R&D to ensure that their products compete in today's fast changing markets. By contrast, the knowledge led businesses rely more on simply "keeping abreast" of latest thinking and technology, understanding what suppliers are providing in the market place and helping customers to make the most appropriate choice of technology for their circumstances. They

rarely push their customers towards "state of the art" technical solutions, which can frequently cause teething problems. Rather they steer clients towards new but proven technology. This group takes a professional interest in research results relevant to their field, but they rely on the product companies to translate research into useful products, systems or services. Thus while this latter group of companies are important to the diffusion of technology their role in the processes of innovation tends to be far less.

Concentrating on the product based NTBF we find that their decisions about new product or process development may arise in one of three main ways:

(1) Innovation led market pull ideas stemming usually from the entrepreneur/company founder. These ideas arise from identifying how two or more previously unconnected matters can lead to solving a problem for industrial customers or otherwise better meeting a market need.

(2) "Me too" market pull technologies, where an entrepreneur has experience of a particular industry, perceives that there are high margins being made and believes that he can serve the same market from a lower overhead operational base and hence return a good profit after charging a lower price. He believes the price margin will win market share. In addition the product he brings to the market usually has several features which differentiates it from competition in the market place. These entrepreneurs often fail to perceive the full complexity and cost of gaining a significant market share.

(3) "Technology push", in which a technologically minded entrepreneur perceives a possible novel use (or uses) for a technical idea he has been working on. He sets up a company to exploit this idea and finds that he has to "create" the market. Although this last category is often perceived as the typical model for UK NTBFs, they are in fact a minority. However, it is quite a common model for academic entrepreneurs.

Once established with their first product developed as a result of one of the above mechanisms, NTBFs need to continue to innovate by developing successive generations of their technology to keep up with rapid changes in the market place. Many product based NTBFs fail to maintain the necessary level of investment in R&D largely because they do not generate profits sufficiently quickly or in sufficient quantity. The fate for these businesses is either to be taken over (which is a common occurrence) or a lingering failure.

While most NTBFs come into existence with a radically new product (apart from the "me too" type) relatively few NTBFs consider developing other radically different products or services. Rather as mentioned above they are more likely to:

- Develop successive generations with steadily improving performance and customer value;
- Develop or licence or otherwise acquire complementary products.

Given this background it is clear that the typical NTBF is not going to have a heavy interaction with Universities or Government Research laboratories. Equally clearly the greatest potential for mutual collaboration to improve the flow of innovation into NTBFs lies with the product orientated business. However, even here where the need (and willingness) to cooperate is greatest there are problems.

By far the greatest of these problems is the disparity between time scales and perceptions of government labs and universities and the research and development needs of the "product" NTBF. The researcher from the 5 star University department is driven by the RAE (research assessment exercise) to deliver a minimum of two papers per year in certain high rated scientific journals. While his/her research time scales are often long (measured in years) the need to generate papers is inexorable which means that even "interesting" short term diversions to help an NTBF with a problem often have to be shunned, particularly as the NTBF will usually not want any results of their collaboration to be published. Furthermore, the NTBF often has tight deadlines for its R&D. The market is moving all the time and factors such as cash-flow militate against a leisurely approach to new product development. Therefore the NTBF is more likely to be thinking in terms of weeks or months as opposed to the academic's years.

If the above analysis were the complete story then clearly there would be no interactions between universities and NTBFs, whereas of course, there are examples of good relations between NTBFs and universities. The problem is that the number of relations involving NTBFs which lead to real innovation and the exploitation of the UK's university intellectual property base is much smaller than it could be. The statistics show that too many of the relationships which do exist are casual and occasional.

The following are some thoughts as to the types of initiatives that might be considered which could lead to a greater level of productive interaction.

## Suggestions for Initiatives

*Create specialist intermediary organisations*

The UK has excellent research at the level of the University and Government research labs and UK NTBFs are not intrinsically poor at innovating. What is missing is the means of generating good and effective communication between the two sides. In Germany there are three levels of intermediary organisation which assist the process of the translation of research to exploitation. They are:

— Max Planck Institute. This is at the "R" end of the R&D spectrum and interfaces better with larger corporate R&D functions;
— Fraunhoffer Institute;
— Steinbeiss Institutes set up largely to serve the R&D needs of the large number of small and medium sized enterprises, most of which cannot afford to maintain an ongoing R&D function. Steinbeiss operations are subsidised and permit collaborative R&D, technical training and access to knowledge relevant to solving technical problems of the nature typically found in commercial operations targeted at the SME.

It may not be appropriate for the UK to follow the German model precisely, but it may be appropriate to see if existing university and public sector research organisations could take on this "intermediary " role. This would mean going well beyond the existing industrial liaison office and contract research activities. Perhaps within a region several universities could "club" together to provide this type of service.

*Change the Research Assessment Exercise (RAE)*

The dysfunctional behaviour of the academic community towards the commercialisation of research is definitely getting worse as the RAE drives Universities to greater concentration on the outputs which generate a good research score. While University research might well have a bias towards the long term "blue sky" type of activity for entirely logical and justifiable reasons, it seems wrong that this should be at the expense of opportunities to exploit research results for the benefit of the UK economy.

Therefore we would argue that the RAE measurable outputs might be adjusted to take account of other factors such as:
— Patents generated;
— Unpublished/unpublishable (because of commercial agreement) but otherwise excellent R&D;
— Transferred research results to Industry;
— "Spin out" company formation from research.

*Create More Spinout Companies*

The UK has a very poor record for spin out companies from its University sector and the results from Government research labs is almost certainly even worse. Traditionally spin outs are seen as companies formed by academics based on their research. Research has shown that few of these companies are particularly successful, but where such a company employs full time professional management this picture tends to change and the companies are more successful.

The advantage of encouraging spinout activity is that the motivation of the individuals concerned tends to be high and this is absolutely essential for the successful exploitation of complex scientific and technological ideas. However, spinout activity does not have to involve the key academics. Experience in several parts of Europe have shown that qualified research assistants, postgraduate students, technical staff and even undergraduates can be successful in this spin out process. In the UK context we know that relatively few PhD students and Research Assistants are likely to find long term careers in the University sector, so why not encourage some of them to exploit the work they have been doing in the laboratory. True, many do not have the desire or the commercial skills, but again there are excellent models (eg UNISPIN, Graduate Enterprise) for overcoming these barriers. Unfortunately, so far, it is not in the self interest of Universities to operate programmes like this.

The advantage of spin out companies is that they tend to have intrinsically good relations between faculty and company technical staff which leads to long term constructive relations with each party having a good idea of the others' strengths and weaknesses.

*Improve Access to the Knowledge Base*

The quantum of skill and knowledge that many NTBFs require to develop a new product or solve a technical problem does not usually involve much "leading edge" research. Conversely it often does involve a sound grasp of current knowledge in one or two narrow areas. Again this implies that it is not the long term involvement of the leading academic that is required and it is why programmes such as the "Teaching Company" and "STEP" programme are so popular amongst SMEs in general and NTBFs in particular.

Therefore we would argue that in the interests of ensuring the good take up of knowledge from the University/Government Lab Sector during the processes of innovation there should be more or expanded schemes of the STEP and Teaching Company nature. It is well known and experienced by ourselves that both of the above programmes suffer from budget limitations as opposed to lack of company demand. Therefore expansion of the schemes will almost certainly be taken up by SMEs.

In addition to the existing two programmes we also perceive a need, articulated by SMEs themselves, for a programme which provides "teaching company associates" for periods of 6–12 months as well as the more

usual two year programmes which are operated currently. This would then provide the continuum from the 2–3 month STEP project undertaken by undergraduates to the full two year teaching company associate programme.

*Improve Access to Finance*

Access to finance for NTBFs is a subject of its own which has been covered by the Bank of England and Tech Stars reports published last year. We gave evidence to the Tech Stars report and were delighted with the balanced approach of this report which highlighted the significance of developing the management team as well as finance the developing growth NTBFs. Therefore, the comments below on improving access to finance should be taken to include measures to ensure that the recipients of such finance have the necessary breadth of experience and skills to develop their business, and if not then they need help in acquiring these skills before finance is injected.

The key measures in relation to improving the exploitation of University research we see would be:

- Developing the SMART programme. It is an excellent scheme but needs to be extended and made more flexible in the amount of grant given both as a percentage and total funding available to a single project. We are aware that many companies awarded SMART grants do not succeed commercially. We are not surprised since no attempt is made to help these often small and immature companies to develop their management skills as well as developing the product or service. This is the main shortcoming of the scheme in our view, and a shortcoming that is amendable to correction.
- The creation of venture capital "seed funds" for speculative developments requiring finance below £250,000. There are very few such funds in the UK and many of those are "drying up" as a result of relative disinterest by the institutional investment sector who see the management time as disproportionate to the amount of finance managed in each fund. We see the development of the Merseyside Special Investment Fund (MSIF) as an interesting regional development in this field. Although the MSIF is more than seed capital it demonstrates one effective way of bringing small scale finance closer to the SME sector through regional economic development interests.
- BTG used to operate "royalty" loans to encourage risky R&D that could lead to interesting new intellectual property. Loans were repaid by way of royalty payments on the exploitation of the arising IPR. In effect they were success loans.
- The recent budget announcement of the creation of a University Venture Capital fund we see as largely irrelevant to NTBFs. Generally we see this fund being used for bringing some longer term research to the stage where it can be taken up by larger companies. Hopefully, it might also be adapted to encourage University spin outs.

*27 April 1998*

## APPENDIX 74

### Memorandum submitted by the University of York

INTRODUCTION

The University of York undertakes research both with EPSRC funding and in collaboration with industry in several disciplines within the engineering and physical sciences remit, including Computer Science, Electronic Engineering, Chemistry and Physics. While we are unable to comment directly on the manner in which companies decide on developing new products and processes and the factors influencing their decisions, our comments are based on our experiences as both a partner in research and a licensor of technology deriving from EPSRC sponsored and other research.

GOVERNMENT FUNDED RESEARCH

As Government-funded research, particularly that funded through the EPSRC, becomes more focused on application, and on Foresight priorities, it is now commonplace for applications for such funding to include reference to, and often active participation by, industrial companies. Although we are still working in areas driven largely by academic curiosity which, as well as resulting in academic publication and development of new knowledge, can from time to time result in new technology for which the University has no potential end-user in view, it is our perception that academic researchers are becoming far more aware of potential commercial applications than they have been in the past. It can nevertheless still be difficult for universities, who are still seen as supply driven, to find suitable licensees for their technology, especially among British owned companies.

GOVERNMENT SCHEMES DESIGNED TO PROMOTE COLLABORATION

There is quite a large number of Government schemes, (very large if you include EU schemes) designed to promote collaboration in and industrial application of research. We find that the plethora of schemes is seen as confusing by industry, especially smaller companies and that the bureaucracy associated with many of them can be off-putting. However, the Teaching Company Scheme is particularly valuable for smaller companies and universities alike.

INTELLECTUAL PROPERTY (IPR)

Ownership of intellectual property remains an area of potential tension in collaborative research and in some ways it is harder to deal with in engineering fields than in other areas of science, as there is a greater tendency in this sector to rely on secret know-how and speed to market rather than patenting. This can make it very difficult for the academic collaborators as publication and the academic mission can be severely compromised. The same would not apply to companies in the chemicals sector. We recognise that industrial collaborators usually want exclusive access to the results of research and we are quite willing to accept this, on condition that provision for appropriate reward to the university and the inventors can be negotiated in the event that inventions provide significant benefits to the company, and that reassignment of technology to the University can be secured in the event of non-exploitation of the IPR.

FINANCE TO SUPPORT ENTERPRISES INVOLVED IN THE APPLICATION OF RESEARCH AND INNOVATION

Finance to support application of research and innovation remains a big problem for both the university and the companies that have spun out from the University. We are involved, with partner universities in our region, in discussions with venture funds and others in an effort to try to address the "development gap", and we look forward to seeing further details of the recently announced University Challenge in the hope that it will address this problem. SMART awards are a useful source of funding for small projects, but are not appropriate in all cases.

ROLE OF THE ENGINEERING AND PHYSICAL SCIENCES RESEARCH COUNCIL IN FOSTERING TECHNOLOGY TRANSFER

The Research Council has adhered to its policy of requiring University recipients of its research grants to be responsible for the exploitation of resulting technology, but in the past it has done very little to support the activity itself. Its latest initiative, the establishment of four Faraday Centres, promises to be a fruitful medium for technology transfer between universities and British based companies. It could also be argued that the Realising Our Potential Awards, rewarding as they do academics who participate in collaborative research with industry, is another indirect way of fostering technology transfer. However, its biggest contribution is clearly the CASE and Industrial CASE studentship schemes, which facilitate doctoral training with at least some relevance to industrial needs, including people exchange and placements of students in industry.

*23 April 1999*

## APPENDIX 75

### Memorandum submitted by Vector International Processing Systems (VIPS) Ltd

VIPS Ltd (Vector International Processing Systems Ltd) is a UK based company marketing specialised software for the oil and civil engineering communities. The company provides consultancy services as required. VIPS Ltd have completed Link Project PN7248 in conjunction with BP, STATOIL, TEXACO and MOBIL. The success of the project has led to the development of computer programs which can be used to optimise reservoir management thereby enhancing hydrocarbon recovery.

1. VIPS has established links with leading universities and heard of LINK through contacts. Participation within LINK was viewed as a prerequisite for company success in the market place. Without LINK unique software for reservoir engineering could not have been developed and VIPS would not now have been in the position to make direct contact with oil companies world wide to promote company expertise.

2. The aim of the VIPS Ltd's involvement with LINK was to develop and validate computer software for reservoir management and at the same time gain a competitive edge in the market place. LINK in this respect has met VIPS objectives.

3. LINK has had a considerable impact. VIPS is now gaining increasing recognition world wide from the new techniques for reservoir management that have been developed. The company now has an increased research profile. Consultancy work with leading majors has increased due to direct LINK involvement.

4. All DTI staff have been extremely helpful in the pursuit of funding and VIPS believe therefore that there have been no barriers that have prevented the company from gaining more from LINK.

5. LINK support is essential for small companies which have a technical innovation that requires promotion in the market place. In the case of VIPS the company had highly qualified experienced personnel to implement the new technologies and LINK support provided the means for establishing the company on an international and world wide basis.

VIPS now looks forward to the future. It is an exciting time for the company which is indebted to LINK for funding and support.

*22 January 1999*

## APPENDIX 76

### Memorandum submitted by Zeneca Group plc

INTRODUCTION

Zeneca is an international bioscience based company which was demerged from ICI almost five years ago and has since grown to be one of the top 10 UK companies by market capitalisation. Its turnover last year was £5.19 billion and its profit before tax £1.081 billion. It is a major investor in research and development—R&D expenditure in 1997 totalled some £653 million—which supports its three principal businesses: Pharmaceuticals, Agrochemicals and Specialty Chemicals.

As a market focused and technology driven company, it has major research competences in a number of fields, in particular the biological sciences, organic chemistry, toxicology, environmental sciences, and all engineering disciplines, particularly chemical and biochemical engineering.

Innovation resulting from successful investment in R&D is regarded as the basis of future profitable growth. The company, therefore, has a keen interest in the health of the UK science base and a strong desire to see the maximum benefit gained from exploiting publicly funded science, particularly that in universities and research councils. Through representation of individuals, it has active involvement with all of the research councils except ESSRC.

1. Zeneca very much welcomes the invitation to contribute to the Science and Technology Committee inquiry into Innovation and Technology Transfer through commenting on the various topics you raise in your letter of 8 April.

2. Before turning to these, may I say there are few things more important than the question of innovation which we in Zeneca see as an essential process of renewal and a major driver of profitable growth and shareholder value. As a market focused and science and technology driven company, our aim is to encourage from the top innovation in every aspect of our activities.

3. Although I note the questions you raise focus primarily on technological innovation, from a general perspective, we in industry have been very much encouraged by the way in which the White Paper "Realising our Potential" was followed by the first Foresight exercise which sought to emphasise the key role of public investment in science in wealth creation. A major thrust of the Foresight exercise was to highlight the continuum of science from basic research through to applicable technology, and strengthen university, research institute and industrial research technology links in the 16 areas which have been singled out as opportune for wealth creation.

4. In fact, we saw interesting parallels between our own research targeting activities, an indispensable mechanism for focusing our research effectively, and the Foresight exercise, since each requires a view of the marketplace of the future and the identification of key areas of science which have the potential to change that by creating new products or processes or by bringing significant enhancements of existing technology. This mechanism requires an interplay between visionary marketing people and scientists and technologists in research and development. We have found that iterative dialogue between them is the best way of achieving a shared view of the future marketplace and products which will have a competitive advantage when created through our research efforts.

5. In fact, we view the Foresight exercise as a macrocosm of our in-house research targeting and an important process of engagement, particularly in those areas where industry and academia have not linked together effectively. As far as our areas of interest are concerned, we have had no complaints on that score. Chemistry, chemical engineering, the biological sciences, (plant microbial and mammalian), and biomedical research are all of vital importance to us and all are areas where we have well developed links with both UK universities and research institutes, particularly those of the BBSRC, MRC and NERC.

6. When it comes to engineering and the physical sciences, particularly chemistry and chemical engineering, not surprisingly, most of our links are directly with the leading university departments which we set up through our individual Businesses and through a central Strategic Research Fund which is managed at Group level but with the active involvement of the Research Directors of each Zeneca Business. In addition, in appropriate cases, we have projects which involve Daresbury, for example. Thus, universities and the Science Research Council Institutes are the main source of our collaborative programmes. Because of the nature of our research, we have had little involvement with independent research and technology organisations.

7. Against that background, we attach great importance to LINK schemes and CASE Awards. We have been successful in securing Quota Awards, for example, from BBSRC and have never found difficulty in generating meaningful strategic proposals. If there are problems in this area, it has been the bureaucracy which has certainly recently improved somewhat in the LINK schemes, although we would, in a spirit of frankness, have to note that the catalyst initiative took so long to come to fruition that we eventually withdrew our original offer to paticipate with the associated funds and used such funds elsewhere[36].

8. In general, we regard LINK as a key mechanism for supporting research partnerships between UK industry and the research base. Particularly pleasing is that, although the focus is on pre-competitive research, projects now require to have an exploitation pathway mapped out. A particularly welcome feature of the LINK programmes is that around 50 per cent of the companies that have been involved are SME's mainly in areas of high technology. Against that background there would be merit in giving serious consideration to bringing together more closely LINK and the Teaching Company Scheme, perhaps through a common board.

9. Given the nature of our in-house research with its emphasis on strategic and applied research, we attach great weight to the question of securing intellectual property rights. We, therefore, ensure that in our collaborations there is clarity about who owns what. Of recent, we have noticed that universities have become much more proprietorial in this area, even when we provide the research funding, but that has not precluded contriving agreements which give exploitation rights to us in return for appropriate rewards for a successful invention. On the whole, such an outcome tends to be the exception.

10. As I mentioned earlier, because of the nature of Zeneca, our main interactions have been with the biological research councils and their research institutes. We really do not have a well formed view of the role of ESPSRC in fostering technology transfer. By its nature it is, of course, more disparate in the areas of science it covers and, unlike MRC and NERC, does not have as clear a mission. Because of our history, we have highly developed links with leading university departments of chemistry and chemical engineering, for example, and have found no problems in contriving direct relationships with key centres of excellence.

11. These are our immediate reactions to the terms of reference of the Science and Technology Committee's inquiry and to the specific topics raised. We would be happy to enlarge on these verbally should you wish to follow up any of them.

*23 April 1998*

## APPENDIX 77

### Memorandum submitted by Zeneca Pharmaceuticals

1. Introduction

Zeneca Pharmaceuticals is part of the bioscience group Zeneca which also comprises Agrochemicals and Specialities businesses. Zeneca Pharmaceuticals employs over 15,000 people worldwide. It has its headquarters in the UK, but over 93 per cent of British production is exported and the business' medicines are used in over 130 countries. Zeneca Pharmaceuticals participated in the LINK project, "Biological application of particle engineering", under the Nanotechnology LINK programme. The project, reference GR/J57889, started on 1 April 1994 and finished on 31 June 1998.

2. How You First Learnt About LINK; The Reasons You Decided to Participate; and How Easy or Otherwise You Found it to do so Initially

We first heard about the LINK scheme through our academic liaison group within the Company and through direct contact with academics. We decided to participate in the LINK project identified above to enable us to continue collaborative research in the area with the School of Pharmaceutical Sciences at Nottingham University on a larger scale than would have been possible without Government funding in what is a speculative and high risk area of science. We did not find it particularly easy to participate in the project initially. The initial negotiations seemed to be unnecessarily protracted, complicated by the need to gain approval separately from the LINK programme committee and the Research Council funding body.

3. Whether Your Involvement in the LINK Has Met the Objectives You Had

The project has only partially met the technical objectives that we had at the outset. Although progress has been made in making, characterising and understanding nanoparticle drug delivery carriers, significant further fundamental work would be required before useful delivery systems could be achieved in what has turned out to be a significantly more complex technical challenge than initially envisaged.

[36] Following a later reappraisal of the situation in September 1998, we decided to support the catalyst initiative but at a more modest level than originally indicated.

4. The Impact That LINK Has Had On Your Company

Some of the technical developments from the programme will be useful in our own on-going drug delivery research and in potential future collaborations in related areas. The project has allowed us to build and maintain links with the top UK School of Pharmacy which has facilitated the recruitment of good PhD students. It has also enabled us to participate in a speculative high-risk advanced drug delivery research project and to build links with several polymer chemistry groups in UK universities.

5. What Barriers, if any, Have Presented Your Company From Gaining More From LINK

During the project, we did not have any particular candidate drugs of our own that we wanted to evaluate as part of the LINK project. However, at times during the project it was difficult to balance the aims, interests and aspirations of all the participants, so that, had we had a suitable candidate drug of our own, we would have found it difficult to propose it for evaluation. At times we also found it difficult to maintain our in-kind work commitment in the timescale required by the project due to competition from our own in-house projects for resources. We were not able to devote significant additional resources to investigating potential speculative applications for our drugs in parallel to the project.

6. Your Overall Assessment of the Scheme

The LINK scheme appears to work less well for precompetitive projects addressing fundamental research, and offers no significant advantage over other funding mechanisms, such as co-operative funding. It is probably better suited to precompetitive development projects that exploit innovations and discoveries by developing products in related areas in parallel by companies with complementary or synergistic interests rather than potentially conflicting ones.

*19 January 1999*

## APPENDIX 78

### Supplementary Memorandum submitted by Shell UK

### Letter to the Committee Specialist from Mr Malcolm Brinded, UK Country Chairman, Shell UK

Thank you for your letter of 28 January requesting brief written answers on the subject of Government funded research and Foresight.

We concur with the Foresight view of the future relating to our business sector and we see it as beneficial that Government supported research has been focused in line with the industry's priorities.

Shell stays abreast of Government funded research. We provide industry representatives for several Government bodies, including research selection panels for the Link programme. We are also approached by research organisations seeking our feedback before applying for Government funding. We have not, however, begun any new lines of research specifically as a result of Foresight outputs.

We have an active programme of research within the Shell Group, orchestrated through our own Group R&D establishment which develops or procures technology on our behalf, and so do not expect Government funded research to be a primary source of new material. It is, however, a useful additional source. Shell Expro has good access to proposals for Government funded research but usually chooses not to co-sponsor. The results of the work cannot normally be kept confidential and so the research is in the same category as Joint Industry Projects (JIPs). Industry has been quick to create JIPs to address recognised needs as they arise.

Shell UK is supportive of the Link scheme and the Teaching Company scheme. Although these are very worthwhile schemes, funding may be spread too thinly to make a big impact. The DTI launched Foresight in 1994 to help it guide innovation in the UK more effectively. Since then, the DTI's innovation budget has been spent according to Foresight's findings.

The main arm of the innovation budget is the LINK programme. It has been recently announced that it is being increased to £220 million. Of this, the allocation for oil and gas projects is £1.9 million this year, and to qualify the project must have at least 50 per cent industry funding. Another arm of the innovation budget is TCS, formerly the Teaching Company Scheme. The spend here is doubling to £6 million and that funds about 400 projects. The oil and gas sector will probably get about 20 of these. Expro's local experience of TCS has been good. Amec, for example, has developed a capability in creating neural networks to model production systems and improve topsides performance. They did this through employing Aberdeen University graduates supported by TCS money.

Current requirements for funding tend to be prescriptive in order to target the public money to research organisations and SMEs. A more generous funding regime, where research work placed with UK universities would attract tax advantages, would almost certainly stimulate more industry support and interaction.

The Link programme provides funding for academics and SMEs and seeks to involve them, along with a company such as ours, in a piece of collaborative research. Care is taken to choose industrially relevant projects and the programme appears well run. There is not yet much of a track record. The teaching company scheme provides an SME with the services of an academic and the support of his/her university department. It provides a real benefit to both and as customers we also benefit.

I trust this provides you with sufficient background but please let me know if I can help further.

*5 March 1999*

## APPENDIX 79

**Supplementary Memorandum submitted by British Telecom**
**Answers to questions from the Clerk of the Committee, following the evidence Session of 13 January**

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### 1. What Percentage of Your Technology is Sourced from Small Companies?

1.1 BT has more than 1,800 external core suppliers ranging from corporations and multinationals to individuals and small businesses. Currently, 69 per cent of our purchasing contracts go to small and medium-sized enterprises, with specific skills, capability and potential. This number is likely to stay static although there will be churn within the supply base as we further consolidate the mix of our suppliers.

1.2 Our purchasing covers a wide range of services from telephone exchange equipment to vehicles, accommodation and stationery. The majority of BT's core voice technology (90 per cent by value) which covers switching and transmission equipment is sourced through contracts with large multinationals companies like Marconi Communications (formerly GPT), Ericsson or Nortel.

1.3 Within the area of data communication networks, where most of the growth in the telecommunications industry is visible, the supplier can be divided into two segments—hardware orientated and software orientated.

1.4 Again over 90 per cent (by value) of the hardware requirements for BT's data network are sources from large multi-nationals companies, like CISCO, Lucent or Nortel. The reminder is purchased from specialist small/medium size companies around the world (ie specialist modem suppliers).

1.5 While a large proportion of the hardware suppliers also provide their specific, proprietary software, BT purchased a significant proportion of its data networking and application software from small/medium size companies around the world.

### 2. What Disadvantages does BT See in Having Small Companies in its Supply Chain?

2.1 BT does not see any disadvantage in having small companies involved in its supply chain. However, BT does operate a global sourcing policy that provides compatibility of products and equipment and is a key criterion that some small companies may find difficult to meet.

2.2 In order to encourage small companies to work with BT, the company has instigated a supply diversity programme. This offer mentoring to small, ethnic companies, positioning their understanding and practices in relation to large multinational companies enabling them to provide their products and services.

2.3 BT also manages supplier capability assessments, designed to increase performance within the company and by doing so equip the company better to deal with fluctuations in future demands and needs of large companies.

2.4 At the same time, BT uses its market standing to improve awareness and best practices in environmental performance. The use of BT's Environmental Generic Standard has been instrumental in managing up performance in this area.

2.5 In addition BT is very active with external agencies and are sponsors of the DTI's "buy IT best practices" which supports small companies in understanding multinationals IT best practice.

3. What is BT's Supplier Selection Process?

3.1 Suppliers

*BT UK spends around £4.2 billion a year on equipment, services and materials. This represents approximately 1 per cent of UK GDP and makes BT one of the largest purchasers of goods and services in the country.*

4. Company Commitment

We use our purchasing power fairly and:

— administer tendering and contracting procedures in good faith; and

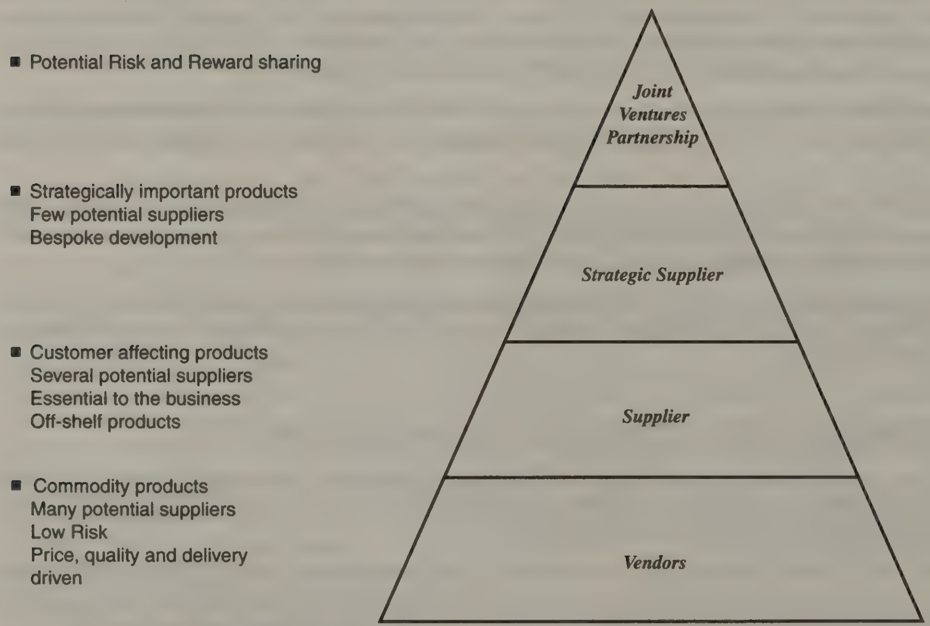
— pay promptly and as agreed.

4.1 BT has an impressive history in the management of its supply base. Many companies around the world approach us to benchmark the way in which we have reduced our supplier numbers and improved the quality of supply whilst reducing whole life costs of the goods and services that we buy.

4.2 To help us segment our supply base within each product area we have developed a Supplier Relationship Framework that takes account of the criticality of supply to BT and the nature of the market place. This enables us to better align our resource against the segmented elements of our supply base.

4.3 This approach provides a commercial edge in the provision of innovative products with a competitive time to market by ensuring that, where appropriate, suppliers are aware of our requirements early in the product life cycle. A closer working relationship with some suppliers will provide the opportunity to minimise capital employed and achieve best value for money from our suppliers in terms of cost, quality and reliability.

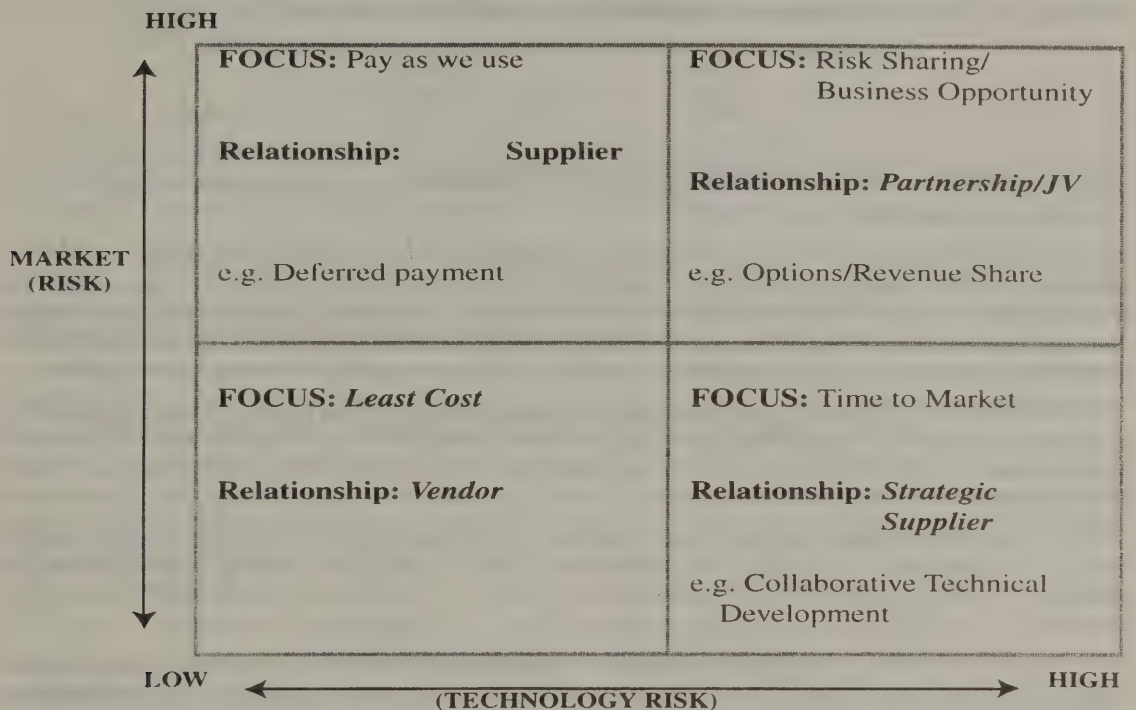
**Figure 1**
Supplier Relationship Framework




5. We manage all elements of supply risk, such as loss of supply or over dependence and decide the most advantageous commercial arrangement. Commercial risk is minimised by developing appropriate investment strategies for each supply area.

5.1 The chart below shows the linkages between the uncertainty in the market and the maturity of the product technology and how this positions our business imperatives of focus, which indicates the most appropriate supplier relationship.

**Figure 2**
**Commercial Risk Framework**




5.2 We continue to develop a thorough and excellent understanding of our suppliers, supply markets and the importance of supply to our customers. This will provide the information to enable us to identify and manage supply risk across the supply chain and to identify surfeits and gaps in our existing and future supply base.

5.3 In order to align key suppliers' business goals with BT's we have developed the Reverse Account Management Programme (RAMP) which is used in conjunction with the Supplier Relationship Framework. Through this programme we identify those suppliers with whom a closer working relationship would provide an earlier view on how technology is evolving and how our networks and systems can make better use of the technology. Working together and pooling expertise allows us to define and be proactive in determining the use of new technologies for the future. Application of the Reverse Account Management Programme across BT enables us to consistently manage these suppliers and drive them in the direction necessary.

5.4 BT is currently establishing the readiness of the supply base to meet the century date change, so that early in 1999 a clear picture of problem areas and remedies can be implemented. Suppliers' conferences which are planned to start in the first quarter of 1999 will address this and other issues such as how we intend to manage diversity in our supply and how new ideas from suppliers will be captured and debated.

5.5 Improvement programmes focused on environmental issues across our activities will be continued and enhanced. They will include fuel and energy conservation, product stewardship and waste management. We are examining the feasibility of applying measures and controls that will enable us to manage environmental responsibilities across the BT supply chain and the introduction of life cycle assessment.

5.6 We benchmark product price, cost and quality along with our processes and practices. This allows us to quantify and reach World-Class performance by adopting or developing best practices. For selected suppliers we seek to negotiate Global Trading Agreements covering specific products/services. These deliver a one-stop commercial deal covering common price, quality, support, and cover all of the appropriate products purchased from that supplier. This effectively leverages the purchasing power whilst displaying BT commitment to the supplier concerned.

5.7 In all our dealings with suppliers, we aim to recognise the legitimate interests of all parties and build a relationship founded on trust, co-operation and continuous improvement, in the knowledge that a supplier is almost certainly a customer and may well be a competitor or collaborator. From time to time we survey our suppliers to ascertain how satisfied they are with BT as a customer. Our suppliers have requested that we do not undertake this survey too often as many are experiencing "survey fatigue".

**Figure 1**

**Percentage Suppliers Satisfied with BT as a Customer**

| *1995* | *1996* |
|---|---|
| 62% | 67% |

Source: Internal BT survey, not undertaken by an external agency.

Sample: minimum 100.

6.To publicly recognise the contributions from our suppliers the BT Investing in Excellence Awards were launched in 1998. There are four entry categories: quality of product and service; innovation and responsiveness; reduced whole life costs and contribution to continuous environmental improvement. Nominations can come from a BT person or directly from suppliers and is open to all our suppliers whether large or small who have excelled in delivering quality, innovation and value for money to the company.

6.1 We are aware of the importance of establishing practices in our trading to demonstrate high standards of corporate citizenship. Our purchasing principles are underpinned by a range of specific policies, procedures and measures related to tendering, contract placement, collusion, environmental protection, social impact and other aspects of supply chain management.

6.2 We are currently reviewing compliance with legal requirements and with voluntary codes of conduct. We are also canvassing the opinions of key stakeholder groups as part of an ongoing review and using the experience of other companies and organisations in an effort to understand and determine industry best practice.

6.3 We follow European Commission guidelines on tendering. Our selection processes allow all potential suppliers that meet specific criteria to have the opportunity to tender and our tenders are always objective and applied equitably.

6.4 Our company commitment is to pay promptly and as agreed. The terms for payment are negotiated and detailed in each contract. To support improvement in this area, we are developing measures to identify instances and causes of failure in the payment process.

7. BT's Purchasing Principles

7.1 We:

- seek to negotiate the most advantageous terms for the company, its shareholders and customers in our business transactions;
- recognise the legitimate interests of all parties and administer tendering and contracting procedures in good faith;
- seek competitive tenders and award contracts on the basis of criteria established prior to tendering. These may include quality, reliability of suppliers and competitiveness of price on a whole life cost basis;
- promote a standard of quality that represents increasing value for money to our customers by ensuring that quality is a consistent and integral part of the procurement process;
- wherever possible adopt technical standards which avoid discrimination in favour of any one supplier;
- operate in accordance with the regulatory conditions applicable to the Company; and
- work with our suppliers to ensure that the goods and services we buy can be manufactured, used and disposed of in an environmentally responsible manner. We aim to minimise the impact of our operations on the environment.

7.2 We will not:

- give unfair advantage to a particular supplier;
- make the award of a contract conditional on a supplier being a customer of BT;
- disclose forecasts or budgets to a prospective supplier unless the information is also available to the supplier's competitors;
- divulge information which, if generally known, might affect the price of BT shares or the shares of its suppliers, customers or competitors;
- allow our people to use their official position within the Company to obtain goods or services for their personal use, at discounted prices from BT's suppliers; and

— accept hospitality on a frequency or scale greater than that which may be neither reciprocated nor let the level of hospitality be allowed to develop to a stage where it may be deemed by other to influence a business decision. The Company will always meet accommodation and travel expenses for employees.

8. Our Goals for the Future

8.1 In March this year 900 suppliers were invited to the launch of BT's Investing in Excellence Awards. Successful ideas covering innovation, environment, whole life cost reduction and health will be rewarded and recognised in November at our awards ceremony to be held in London's banqueting hall.

8.2 Improvement programmes focused on environmental issues are in place including fuel and energy conservation, product stewardship and waste management. We are examining the feasibility of applying measures and controls that will enable us to manage environmental responsibilities across the BT supply chain and the introduction of life cycle assessment.

8.3 We seek to establish "world class" standards of "Corporate Citizenship" and ethical behaviour across all activities and initiatives are being implemented to achieve this. A range of specific policies, procedures and measures relating to tendering, contract placement and supplier relationships are in place.

8.4 Product price, cost, quality and processes and practices will be benchmarked. We will reach World-Class performance by adopting or developing best practices. Global Trading Agreements, covering specific products/services will deliver a one-stop commercial deal covering common price, quality, support and terms for all products purchased from selected suppliers.

9. Outside the University Programmes what Relationship does BT have with Colleges?

9.1 BT's main activity with the Higher Education sector is our Higher Education Awards Scheme (formerly known as University Development Awards) which provides for awards of up to £100k out of a total annual budget of £500k. BT initiated this awards back in 1993 and we are running the scheme again this year. All UK institutions awarding degrees were sent an invitation pack in November for final submission in February 1999.

9.2 BT's Community Partnership Programme in close liaison our Sales and Marketing organisation manage Higher Education Conferences. The last event was held in November 1997 "Higher Education in the Learning Society" and attended by 70 delegates from UK universities. The conference was addressed by Sir Ron Dearing and Tony Clarke, Director of Higher Education, DFEE.

9.3 A similar conference is planned for March of this year with the theme of "Regionalisation Vs Globalisation". Speakers include Richard Carborn, Minister for RDA's and Dr Anne Wright, Chairman of the University for Industry, BT intends to launch its booklet "Catalyst in Higher Education" at this event which provides case studies on previous BT Higher Education Award Winners.

10. Why does BT Ignore Certain Universities in their Recruitment Process?

10.1 BT does not operate a policy in which certain universities are ignored. Our promotional literature is sent to all Universities, our brochure line and Website are available to all, we also advertise in the national press and other specialist publications, which have wide coverage. In 1998 these activities resulted in applications being received from all Universities and BT recruiting from over 90 different institutions.

10.2 When we undertake additional work to recruit undergraduates it is focused on around 30 Universities. The rationale for selecting these Universities is based on several factors including:

— the outcomes of the Funding Council's Research Assessment Exercise (REA);
— the outcomes of the Funding Council's Teaching Quality Assessments (TQA);
— the undergraduate entry requirements;
— the relationships that have developed over time with particular departments with whom we have undertaken research projects;
— geographical links;
— company strategies, eg globalisation leads to us increasing our activities at European Universities; and
— company policies, eg equal opportunities/diversity.

11. Where has BT seen Policy Change on Government Bodies as a Result of its Input?

11.1 We generally provide input to consultations (eg Future of Foresight, Committee of Inquiry into HE etc etc) independently (ie as BT) and also through channels such as the IEE, Royal Academy of Engineering, CBI etc.

11.2 Based on past experience, BT is not aware that any policies have been changed based on its input. However on a number of occasions the intent of our submissions have been adopted in spirit if not to the letter.

12. PEER REVIEW

12.1 We actively participate in the academic peer review process through membership of the Research Council User Panels, programme management/review groups etc. In general these work well combining the academic viewpoint with the commercial/industry view.

*8 March 1999*

## APPENDIX 80

### Supplementary Memorandum submitted by Barclays plc

1. In 1997 Barclays conducted internal research into the innovation sector, which confirmed innovative businesses as an important market segment both for the future economy and as a source of income generation for the Bank. Whilst innovation defies easy definition, there were certain key categories of customer that displayed innovative characteristics, namely those:

- engaging in research and development;
- evidenced by fast-growth;
- in technology-based industries.

Such was the importance attributed to this sector that the bank established a central Innovation Unit in November 1997, with the objective of establishing a network of Centres of Excellence to support the needs of these businesses.

The research identified that there were certain geographic factors that contributed to the success of such businesses, such as proximity of university research facilities, availability of science parks and business incubator premises and an effective network of support agencies (accountants, lawyers, Business Links, business angel networks, patent agents etc).

Other service providers offered a blanket approach to serving the "high-tech" market through, for example, the designation of several hundred "high-tech managers" throughout the country. Barclays however, felt that a more effective way to serve the needs of growing enterprises and to stimulate further growth was to focus attention in areas of critical mass where Innovation Centres of Excellence could position themselves as an integral part of the support infrastructure.

The focus on Innovation has been underpinned by the most recent findings based upon research (carried out during the first quarter of 1999) of 600 mid-corporates with annual turnovers of between £1 million and £100 million. The net percentage[37] of businesses surveyed who anticipated an increase in business activity during the coming year was +64 amongst innovative businesses as against +41 amongst their non-innovative counterparts. In addition levels of economic optimism were much greater amongst innovative businesses (+22 as against +8 for the non-innovative respondents).

2. During 1998, 15 Innovation Centres of Excellence were established with the objective of strengthening the local network contacts and providing a comprehensive range of banking services to meet the needs of businesses through all stages of their growth cycle. Annex 1 provides a list of the locations of these Centres.

There are no current plans to extend the number of Centres, although this will be regularly reviewed in the light of customer demand.

3. As indicated above, the Centres have a great deal of expertise in dealing with customers who share similar needs and frequently operate in similar industries. This level of understanding of the customers' business and the enhanced relationships with other support organisations enables the Innovation Managers to offer guidance, referrals and appropriate finance to meet the needs of innovative businesses as they grow.

Research is currently being undertaken to determine more closely the needs of fast-growth businesses, in particular, in order to inform the development of additional banking solutions.

4. The relationship with research facilities and technology transfer agencies is seen as a critical component. In addition to promoting greater liaison on a local basis, Barclays have recently agreed the placement of three management secondees to:

- London Lee Valley Business Innovation Centre;

[37] Net percentage defined as percentage of those stating an increase less percentage of those stating a decrease.

— Emerson Green Science Park, Bristol (Chief Executive position to oversee the development and commercialisation of this new facility);

— UK Science Parks Association (Chief Executive position to expand Barclays links in the technology transfer arena and promote the role of science parks both within and outside the UK as a stimulant to inward investment).

5. At this stage it is too early to comment on the success of the Centres, as promotion of this initiative on a national scale has been relatively low key to date. This will be rectified during the second quarter of 1999, with the production of a customer brochure and selected press releases.

*26 March 1999*

**Annex 1**

BARCLAYS' INNOVATION CENTRES OF EXCELLENCE

Bristol
Cambridge
Cardiff
Coventry
East London
Edgware Road & Marble Arch
Enfield
Glasgow
Leeds
Leicester
Manchester
Newcastle
Oxford
Teesside
Thames Valley

## APPENDIX 81

**Letter to the Clerk of the Committee from the Department of Trade and Industry, following the Evidence Session of 24 February**

Thank you for your letter of 3 March addressed to Mr Foster, requesting further clarification on three points following the evidence given by Mr Byers and Mr Battle to the Select Committee. I must apologise for missing your deadline.

1. Your first point concerned a survey of undergraduates that Mr Byers mentioned which showed that far fewer UK under-graduates would consider setting up their own business on graduation than their US counterparts. [Q.1196 in the transcripts]. Unfortunately, we are unable to provide the source of this survey.

2. As requested, I sent a copy of the Competitiveness White Paper Implementation Plan to you on 11 March.

3. With regard to your third point, details of the typical background of ITCs and the methods used to recruit and select them are as follows:

> Innovation & Technology Counsellors (ITCs) have been (and continue to be) openly recruited. Typically, Business Links have used professional recruitment consultants and have advertised in the national broadsheets.
>
> Although there is a wide age range among the ITCs—from early thirties to early sixties—most are between forty five and late fifties. Some have taken early retirement from surprisingly senior posts in industry and are happy to work for a lower remuneration than they have enjoyed previously because of the variety and interest that the job presents. Only one ITC (Doug Ponsford OBE) is an ex-civil servant. Typically, they have worked in industry, many have run their own businesses and/or worked as consultants. Collectively, they once estimated that they can boast well over a thousand years of industrial and business experience.
>
> Business Links are responsible for setting the selection criteria when recruiting. DTI have developed a modular programme "Developing Excellence" designed to equip BL Business Advisers with a broad range of counselling and business skills. In addition, DTI have introduced National

Standards of Professional Competence. These are aspirational standards for Business Links to use as templates for the development of personnel in specific roles.

I hope that this information is helpful. Please do not hesitate to contact me if you require any further information.

*6 April 1999*

## APPENDIX 82

**Letter to the Clerk of the Committee from Professor Richard Brook, Chief Executive, the Engineering and Physical Sciences Research Council**

ENGINEERING AND PHYSICAL SCIENCES BASED INNOVATION: FARADAY PARTNERSHIPS

Thank you for your letter of 17 March 1999 regarding Faraday Partnerships. The answers to your questions are as follows:

*How many new Faraday Partnerships are planned?*

EPSRC has made financial provision for four new Partnerships to be launched late 1999, to add to the four pilot partnerships launched in 1997.

*How much funding is available? Over what period?*

Each partnership receives £1 million to invest in academic research, plus research studentships (nine in the steady state). It is anticipated that these funds will be spent over a four-year period, which is deemed an appropriate time to catalyse the partnership. In addition to the £1 million of guaranteed funding, each partnership is free to bid competitively against appropriate schemes (such as LINK and TCS). EPSRC funds go solely to the academic partners (apart from £50k set-up costs). DTI funding is intended to secure industrial participation and technology transfer.

*Who is responsible for managing the process of expanding the Faraday network?*

DTI is taking the lead—but EPSRC is closely involved in all details of the planning.

*Who will review the proposals and decide on the awards?*

We favour the process used successfully for the four pilot partnerships. An expert panel (with independent representatives from academe and industry, plus DTI and EPSRC representatives) short-listed outline proposals. Fifteen partnerships on the short-list then submitted full written proposals, and were interviewed by a board—who selected the final four.

*Who will control the funding and manage the grants?*

EPSRC funds are allocated direct to partnership academic groups, according to standard research grant procedures.

*How will EPSRC and DTI participation be coordinated?*

There are effective working relationships between appropriate DTI and EPSRC officials, and partnership Directors. EPSRC has no desire to get closely involved with the management of individual partnerships, but will monitor best practise.

*Will other Research Councils be included?*

EPSRC would welcome the involvement of other research councils, or government departments, where appropriate. We are leaving DTI to solicit such involvement.

*What is the "network" element of the programme and how will it be managed?*

Faraday Partnerships are based on the concept of active partnerships between industrial and academic partners. The pilot partnerships are demonstrating admirably how effective networking can be pursued through partnership meetings, the internet, and newsletters. It is up to the individual partnerships to manage their networking activities.

*What input have DTI and EPSRC made to the development of the programme so far?*

The programme was developed jointly by EPSRC and DTI, with a coordinated call for proposals in 1997. Unfortunately DTI's budgetary position meant it was not possible for them to fund the pilot partnerships (although they were involved in the selection), and EPSRC decided to proceed with the pilot phase alone. DTI is now proposing to offer some funding to the four pilots, to complement EPSRC funding.

*What are the key objectives and performance criteria?*

The key objective is to catalyse the flow of expertise and relevant knowledge from academe to industry. The role of the "intermediary" (an IRO or similar body) is to interpret the needs of partnership companies, and commission relevant research and training—and to manage the transfer of research results and postgraduate researchers to industry. The key performance criteria will be the increased take-up of research results and the increased recruitment of postgraduates by partnership companies.

*Who will be responsible for monitoring and evaluation?*

EPSRC has been monitoring the performance of the pilot partnerships. Progress reports can be made available, if required. Responsibility for monitoring and evaluation of the overall scheme should be carried out jointly by DTI and EPSRC.

Please let me know if you require further information.

*13 April 1999*

## APPENDIX 83

**Supplementary Memorandum submitted by the Engineering and Physical Sciences Research Council**

The Faraday Partnership initiative is aimed at promoting improved interactions between the UK science, engineering and technology base and industry through the involvement of intermediate organisations. Qualifying intermediate organisations must be able to demonstrate an existing and strong connection with both industry (particularly SMEs) and with academia.

The first four Faraday Partnerships were set up by EPSRC in 1997. They had been intended as a joint venture between EPSRC and DTI but funding constraints the time prevented DTI involvement.

DTI is now in a position to participate fully in Faradays and has announced its intention to fund four new Partnerships each year for four years. Along with the four EPSRC funded partnerships, this will take the total to 20 by 2003. DTI are providing additional funds to the current four partnerships to enable them to enhance their industry facing activities.

Under the current call, announced by Stephen Byers on 14 September, outline proposals have been invited to set up four new Partnerships. EPSRC will provide up to £1 million to each over four year. DTI will provide up to £1.2 million over three years, with the possibility of further support after that time.

*18 November 1999*

## APPENDIX 84

**Memorandum submitted by the Department of Trade and Industry**

### ENGINEERING AND PHYSICAL SCIENCES BASED INNOVATION: FARADAY PARTNERSHIPS

*How many new Faraday Partnerships are planned?*

Agreement has been reached in principle to establish four new Faraday Partnerships in each of the financial years commencing 1999–00, such that by the year 2003, there should be 16 new Faraday Partnerships in being or in the process of being created, in addition to the four Partnerships that were established in 1997.

*How much funding is available? Over what period?*

Funding has been earmarked from the DTI Innovation Budget that will allow DTI to support each new Faraday Partnership for up to £400k per year initially for three years but with the possibility of a further two years funding if progress is satisfactory. In addition, DTI intends to offer the existing four Partnerships (see Annex A) up to about £250k per year in order to put in place those aspects of the Partnerships' activities that are currently constrained by the fact that their EPSRC funding necessarily focuses on the "upstream" research-based activities. DTI funding will pay for strengthening the management of the Partnerships and

enabling them to employ "technology translators"—people who can act as two-way interfaces for knowledge and technology transfer.

DTI funding is on the assumption that each Partnership should have at least two major sponsors for example, DTI and EPSRC. The sponsors' interests in promoting research and exploitation should be mutually complementary so that Partnerships are encouraged to carry out relevant research, development and other work aimed at new product introduction. As the concept of Faraday Partnerships widens and develops, it is hoped that other Departmental or Research Council sponsors will wish to join DTI and EPSRC—even to the extent of establishing partnerships that are sponsored by neither of the two original sponsors. In this case maintaining the quality of Faraday Partnerships will be a key feature and may necessitate the establishment of mutually acceptable quality guidelines.

*Who is responsible for the overall process of expanding the Faraday Partnership network?*

The Management Best Practice Directorate, DTI (Director, Dr Ken Poulter) is currently in the lead for DTI's interest for Faraday Partnerships. They work closely with EPSRC, particularly Dr David Clark, Director Engineering and Science, in jointly working up policy on Faraday expansion. The Office of Science and Technology, and Innovation Policy and Standards Directorate in DTI also have interests from a budgetary and policy point of view.

*Who will review the proposals and decide on the new awards?*

The selection process for new Faraday Partnerships will follow the model that was established by EPSRC for the initial tranche in 1997. From a set of outline proposals a limited number of perhaps 16–20 will be selected for developing full bids. The selection panel will comprise senior representatives of the sponsoring agencies, OST, members of the academic and industrial communities and the chairman of the LINK/TCS Board (Dr David Smith) all under the chairmanship of Mr Robert Foster, Director Innovation Policy and Standards DTI.

*Who will control the funding and manage the grants?*

Direct funding for new Faraday Partnerships is likely to be managed under the terms of a DTI grant offer letter. Partnerships will claim against validated expenditure in line with their bidding proposals. Where Faraday Partnerships bid into existing schemes such as LINK, TCS, Research Council grants, Framework Programmes etc, these will be administered within the normal processes for each scheme.

*How will EPSRC and DTI participation be co-ordinated?*

Sponsors will have the right to be represented at (quarterly) management meetings held by Faraday Partnerships. In addition, there will be an annual "best practice" meeting where all the Faraday Partnerships will report on progress and present ideas for improving best practice across the network. DTI and EPSRC will play a leading role in bringing the partnerships together on this basis. As the full national network of Faraday Partnerships develops, we expect that it will be co-ordinated by regular meetings of managers and sponsors, in a manner analogous to the co-ordination of Postgraduate Training Partnerships at present.

It is not envisaged that sponsors will play a significant role in the day-to-day management of Faraday Partnerships, indeed, part of the ethic is that partnerships should be largely encouraged to develop their own ways of working.

*Will other Research Councils be involved?*

The active participation of any other sponsors will be welcomed, not only Research Councils but also other Government Departments. DTI and EPSRC will put effort into encouraging sponsorship from more sponsors as the Faraday network expands.

*What is the "network" element of the programme and how will it be managed?*

The underlying ethic of Faraday Partnerships is to use exising mechanisms and processes to achieve better exploitation of the research base than would otherwise be possible. It follows therefore that the hub partners of each partnership must maintain active networks both in the research base and in the industrial user communities, extending into intermediary organisations and into suppliers of capital. Networks will be managed throught the use of specialist and topic based clubs within the Partnership, involving any interested partner or linked organisation. Faraday Partnerships will be encouraged to operate on as broad a basis as possible within their regional or sectoral bases in order to encourage understanding and assimilation of the knowledge that they are bringing forward into the wider research and industrial communities. DTI proposes

to engage a third-party organisation to ensure that the networking and best-practice aspects of partnership management are thoroughly disseminated.

*What input have DTI and EPSRC made to the development of the programme so far?*

The fundamental philosophy of Faraday Partnerships is based on the outcomes of the Prince of Wales's Working Party on Innovation which made recommendations supporting the establishment of "Faraday Centres" in 1991. DTI and EPSRC were unable to support that concept at the time, but instead established the Postgraduate Training Partnerships (PTPs) as a joint initiative to encourage universities to work with independent research and technology organisations (RTOs) through the medium of PhD students based in the RTOs themselves and carrying out industrially-oriented research. There are now eight PTPs, each of which supports about 25 "PTP Associates" under joint DTI/EPSRC funding arrangements (see list at Annex B). The Associates receive additional training and industrial experience during their PhD. They have a record of PhD thesis completion that is better than average and around 40 per cent join industry on completion.

DTI and EPSRC recognised that PTP did not offer the full span of knowledge and technology transfer envisaged in 1991 and, in 1996, jointly worked up the initial policy and guidelines for the creation of Faraday Partnerships. DTI was unable to fund the initial round of Faraday Partnerships that commenced work in 1997 but it is now intended that we offer up to about £250k per year to each of the existing four Faraday Partnerships to fully implement the concept as originally envisaged. DTI has encouraged Faraday Partnerships to work closely with existing schemes such as LINK and TCS and to build relationships with the business support organisations such as Business Links and the fledgling RDAs. EPSRC has also made available three CASE awards per year to each Faraday Partnership—to be treated essentially as Postgraduate Training Partnership awards—and the first students in receipt of these attended the annual PTP Conference at Warwick University in December 1998. DTI is encouraging the existing Postgraduate Training Partnerships to consider how they might migrate towards the Faraday Partnership model as their current funding expires, but on a "without prejudice" basis. Faraday Partnership status will be awarded on merit.

*What are the key objectives and performance criteria (for the individual partnerships and the scheme as a whole)?*

Please see the attached Annex C.

*Who will be responsible for monitoring and evaluation (of the individual partnerships and the scheme as a whole)?*

Management Best Practice Directorate, DTI will be responsible for monitoring and evaluating the DTI expenditure on Faraday Partnerships, with the assistance of the Assessment Unit in the Innovation Policy and Standards Directorate in DTI. For EPSRC the monitoring and evaluation will be carried out under the direction of Mr David Schildt, Head of Cross Programmes Directorate. DTI and EPSRC will jointly review progress of the Faraday Partnerships and will consider publishing regular reports.

*January 2000*

## ANNEX A

FARADAY PARTNERSHIPS—THE FIRST FOUR

The Prime Faraday Partnership (Products Comprising Interdependent Mechanical and Electronic Parts) is led by the Universities of Loughborough and Nottingham, together with Pera Technology.

This Partnership serves the growing industry of systems builders providing complex electronic/mechanical hybrid assemblies used for processing, sensing and actuation in products such as cars, aircraft and domestic appliances.

The White Rose Faraday Partnership for enhanced Packaging Technology is led by the Universities of Leeds, Sheffield and York with Pira International and Cambridge Consultants Ltd as core partners.

This Faraday partnership was established to focus on better use of packaging materials providing greater customer benefits in product design and reduced environmental impact through reduced weight and better recycling; and packaging manufacture to allow rapid response to customers requirements.

The INTErSECT Faraday Partnership (Intelligent Sensors for Control Technologies) is led by Sira Ltd and NPL.

INTErSECT is initiating new research and ways of disseminating information on intelligent sensing and measurement systems, particularly to meet industrial requirements for analysis, control and monitoring of manufacturing processes using non-invasive methods.

The 3D-MATIC Faraday Partnership (3D Multimedia Applications and Technology Integration Centre) involves the University of Glasgow and the Turing Institute.

The 3D-MATIC Partnership will enable specialist SMEs to gain access to advanced 3D digitisation technology and 3D applications. Potential applications are varied including engineering, computer aided design, automobiles, design studies for clothes, the film and TV industry and companies specialising in automation and games software.

**Annex B**

### Postgraduate Training Partnerships

Each Partnership involves a single RTO working in collaboration with a single HEI at which the PTP Associates register for a PhD. Eight PTPs are in operation (the five indicated with an * have been in operation since 1992) giving a steady state complement of around 25 Associates per partnership and around 200 overall.

The PTPs, and their areas of research are:

— *BTTG—Leeds University—Biotechnology and materials; novel pollution treatments; artificial intelligence in colour measurement.

— *BHR Group—Cranfield University—Fluid mixing and mass transfer; process intensification; separation and sealing technology; concurrent engineering.

— *EA Technology—UMIST—Energy-based technologies; electrical power distribution; material sciences; environmental engineering and resource management.

— *Sira—University College London—Instrumentation and control; intelligent imaging systems for analysis, inspection, security and surveillance.

— *WRc—Imperial College of Science, Technology and Medicine—Environmental management; water treatment technology; waste water process and control; plant and pipelines.

— TWI—Cambridge University—welding and joining technology for metals and non-metals, surface engineering, cutting, structural integrity, materials engineering, and non-destructive testing.

— CERAM Research—Keele University—processing of particulate materials, novel ceramics and cements, fuel cells, manufacturing improvements.

— National Engineering Laboratory—Strathclyde University—underpinning technologies for the energy sector, flow management, fluid properties, heat transfer, renewable energy, structures and internal combustion engines.

**Annex C**

## NEW FARADAY PARTNERSHIPS—PROPOSED OBJECTIVES

### Top Level Objectives

1. The top level objectives for Faraday Partnerships are encapsulated within the Faraday Principles [38] that were set out in the 1993 White Paper:

— the two way flow of industrial technology and skilled people between the knowledge base and industry;

— partnerships between industrially-oriented research organisations and the science and engineering base;

— core research underpinning product and process development;

— industrially-relevant postgraduate training.

### Programme Objectives—the Network of Faraday Partnerships

2. The Objectives for the Network as a whole are to:

— establish a network of 20 Faraday Partnerships by 2003;

— at least 50 per cent. of these to be related to sector clusters in their region or adjacent regions or implementing key objectives in regional innovation or economic development plans;

— by Autumn 1999 have developed arrangements which will allow the network to develop a national profile;

— to build a 10 per cent year on year increase in awareness of Faraday Partnerships by relevant businesses.

[38] "Realising Our Potential" 1993.

PROGRAMME OBJECTIVES—INDIVIDUAL PARTNERSHIPS

3. The key strategic objectives of the programme is to establish Farady Partnerships built on the Faraday Principles, which have the following characteristics:

— assembled around a suitable hub partner (eg a university, RTO, Government Agency or private sector laboratory) a group of research organisations, intermediaries and business users with a common sector or technological interest who wish to work together to research and exploit topics of mutual interest;

— focused on sectors or technologies of national and regional priorities identified through Foresight, regional cluster or as important in a knowledge drive economy;

— the partners sharing a common vision and an agreed strategic and business plan for the partnership;

— using the existing support mechanisms (eg Research Council awards, European Framework progammes, European Regional Development Fund and European Structural Funds, LINK TCS, PTP/CASE, Smart) in an effective and co-ordinated way to bring work in the science and engineering base to market in a timely fashion especially by leveraging human and financial resources to take the work into user businesses;

— involve other business support partners who can add value to the work and its wider dissemination—for example through clubs, networking, use of "technology translators" and by providing access to other services such as venture capital and help with business and management development;

— use or create the "PTP ethic" so that high quality industrially-oriented research students carry out PhD level work within the Partnership and are given industrially relevant training that will improve their employability in business (and particularly in firms within the Partnership; and

— work with business support organisations—especially Business Links, Regional technology Centres, Regional Development Agencies and organsations such as university regional offices and Industrial Liaison Officers; Institutes for Enterprise; the Teaching Company Directorate and TCS Centres for Small Firms to ensure a two-way flow of information and opportunity between the Partnership and the wider business community.

PERFORMANCE

4. Each prospective Partnership would be expected to produce a business plan for at least the first 5 years of operation that would include specific and testable objectives, showing how it would progress research, exploitation and new product development in its field.

5. The specific aspects of performance would include:

(i) better interfacing between research and exploitation, especially in foresight-related topics and topics relevant to the knowledge driven economy (including the support of local clusters).

(ii) about 200 postgraduate research associates per year trained in technologies important to business and to a standard that industry values and wishes to recruit;

(iii) each Partnership to have work in hand on about 6 new product/process concepts at any one time, developed by consortia of organisations at the academic—industry interface who are willing to continue working together regardless of the public sector support that is available;

(iv) providing a joint sectoral and regional focus for research and exploitation, adding weight to the Regional Innovation Strategies now being developed and future regional economic strategies;

(v) feedback into HEI research and teaching programmes to inform academic staff about industrial needs;

(vi) the establishment of low risk entry into the academic-industry interface for SMEs who have had relatively little previous exposure to research;

(vii) better linkage between the various elements of public sector support available to participants; and

(viii) brokerage—of ideas, people and resources—to increase the effectiveness of the research/exploitation process. Particularly important here are exchanges of personnel between industry and academia and between firms in supply chains.

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